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ABSTRACT

This document was developed to provide eighth-grade teachers in New York City with a sequence of instructional activities in science. The major portion of the guide is divided into four instructional units. The first unit, "Chemistry," includes lessons and activities on liquid solutions, suspensions and emulsions, acids, bases, neutralization, and air pollution. Unit II, "Physics," deals with energy, force and work, machines, and density and pressure. Unit III, "Biology," addresses digestion and absorption, circulation, and respiration, excretion, and behavior. The final unit, "Earth Science," pertains to the atmosphere and weather. Each section includes background information for the teacher, objectives, procedures for activities and experiments, homework assignments, and an appendix. The appendices contain test items that could be used to evaluate the effectiveness of the unit. (TW)

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SCIENCE

GRADE 8

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SCIENCE

Grade 8

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FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, to search for, and to discover scientific ideas which will meet the demands of a changing world.

The new science courses of study for grades 7, 8, and 9 are part of a K-12 sequential science program. It is based upon the sequential development of scientific concepts from four major science areas.

This bulletin represents a revision of grade 8 science based upon five years of careful experimentation in the classroom. It is designed to provide a unique science course of study for youngsters in an urban environment and to meet the needs of students of varying abilities.

The science program, of which this bulletin is a part, envisions in-service training of teachers in schools and districts.

SEELIG LESTER
Deputy Superintendent of Schools

June 1968

ACKNOWLEDGMENTS

In June 1961, the Curriculum Council approved the curriculum project for *Science: Grades 7-8-9*. The planning and design of each year of the science project were under the direct supervision of William H. Bristow, Assistant Superintendent, Bureau of Curriculum Development; Irving Anker, Assistant Superintendent, Office of Junior High and Intermediate Schools; and Samuel Schenberg, Director of Science.

To explore the various problems involved in the preparation of a new course of study for the junior high school segment of the K-12 science program, a curriculum advisory committee was appointed. At that time, the Science Curriculum Advisory Committee consisted of:

Martha Finkler, Acting Associate Superintendent, Junior High Schools
Seelig Lester, Assistant Superintendent, High Schools
Samuel Schenberg, Director of Science; Chairman
Isidor Auerbach, Principal, John Jay High School
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Walter W. Wolff, Principal, William Cullen Bryant H.S.

Samuel Schenberg, Director of Science, the director of the project, provides the leadership and coordination for committees and individuals involved in the project.

To explore the various problems involved in the preparation of a new course of study (long and short form) for the junior high school segment of the K-12 science program, curriculum committees were established. The contributions and expertise of their members are gratefully acknowledged.

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The members of the committee for the short form were:

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The members of the curriculum committee who prepared the present combined grade 8 revised version of the long and short form during the summer of 1967 were:

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Our sincere thanks go to the teachers and supervisors who took part in the tryout of early versions of grade 8 science materials. Deep appreciation is expressed to:

Mona Able, J.H.S. 189Q; Martin Beale, J.H.S. 143X; Henry Bedmarksi, J.H.S. 217Q; Daniel Brandon, J.H.S. 216Q; Morris Gartner, J.H.S. 216Q; John Hodnett, J.H.S. 190Q; Martin Kark (deceased), J.H.S. 217Q; Ray Kawalski, J.H.S. 172Q; George Mortesi, J.H.S. 189Q; Renee Sands, J.H.S. 104M; Perry Sanders, J.H.S. 82X; Ernest Streicher, J.H.S. 252K; Pearl Strom, J.H.S. 143X; Bert Valenti, J.H.S. 190Q; Howard Wagner, J.H.S. 22X; Jules Weisler, J.H.S. 217Q; Arlene Wilson, J.H.S. 109Q.

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Max Hershberg, Assistant Principal, was assigned to the Office of Science Education, 1966-67, to supervise the processing of feedback information. He assisted materially in the development of this new grade 8 science course of study.

Members of the staff of the Office of Science Education and of the Bureau of Curriculum Development have served as consultants. These

members are: Alfred W. Leichtman, Curriculum Coordinator for Intermediate and Junior High Schools, Bureau of Curriculum of Development; Robert L. Lipton, Assistant Director of Science, Office of Science Education; Harry Milgrom, Assistant Director of Science, Office of Science Education; Julius Schwartz, Consultant in Science, Bureau of Curriculum Development; Leonard Simon, Assistant Director (acting), Bureau of Curriculum Development.

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Aaron N. Slotkin, Editor, Bureau of Curriculum Development, supervised printing production. Elena Lucchini prepared the manuscript for the printer and was responsible for the page layout and most of the illustrations.

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Introduction

This bulletin is part of a sequential K-12 science curriculum development program which is currently under way and involves the cooperative efforts of the Office of Instruction and Curriculum, the Office of Science Education, and the Bureau of Curriculum Development.

The science program for grades 7, 8, and 9 was prepared originally for experimental purposes in two versions for each grade. Both forms are now incorporated into this one bulletin which offers flexible science programs for all youngsters. It supersedes *Science: Grade 8* (Curriculum Bulletin No. 3 [a, b, c, d], 1964-65 Series).

An Innovation

The common science learnings developed in this bulletin are basic to scientific literacy for all students. However, all students have different needs and abilities. There is a sizable group of students, approximately 20%-25% of the total, who have achieved limited understanding when compared to other students. For a variety of reasons, these students read below grade level and have difficulty in maintaining themselves in school. They are often referred to as the inner-city child or the educationally disadvantaged. They are the ones who here found little success and little meaning in school and are often the early dropouts But there is potential in this group that can and must be nurtured.

The materials in this bulletin represent a major breakthrough by the New York City Board of Education to provide a new and promising approach to a solution of this important social and educational problem. It provides a basic set of science experiences to assure a common, fundamental depth of understanding for all students. To attain this objective, the bulletin recommends more class time with more opportunities for individual experimentation for the inner-city child. In addition, numerous *supplementary* science activities and investigations are included for those students who are motivated and can proceed at a more rapid rate to follow an enriched science program.

OBJECTIVES OF THE JUNIOR HIGH SCHOOL SCIENCE COURSE OF STUDY

The objectives of the junior high school science course of study reinforce the aims of general education and seek to have the pupil continue to:

- develop the concepts, skills, knowledges, and attitudes begun in grades K-6
- develop a firm scientific foundation, including laboratory skills, upon which the program in grades 10-12 can be built
- explore the various scientific disciplines to develop individual interests and abilities
- understand science as a unified whole by perceiving interrelationships among the four fields of science
- appreciate the role of science in the progress of civilization and in the development of our technological society
- understand the methods employed by the scientist in attacking problems affecting our health and welfare
- apply scientific methods and attitudes, where possible, as a way of life
- explore the possibility of a satisfying and challenging career in a scientific field.

Special emphasis is placed upon:

1. **CONCEPTS.** Understanding the important concepts inherent in each of the four scientific disciplines as well as the interrelationships is developed. Biological concepts are treated in broader perspective because they are based upon fundamental concepts in chemistry and physics.
2. **THE SCIENCES.** Units of fundamental science content from chemistry, physics, biology, and the earth sciences are presented separately in the seventh, eighth, and ninth grades. Each unit is developed lesson by lesson, building upon previous concepts, and involving the students in problem-solving situations. Thus, the internal structure of each science is maintained.
3. **LABORATORY WORK.** Science is considered a major subject in the junior high schools of New York City. In grades 7 and 8, it is scheduled for at least four periods per week, including one labora-

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tory period in every four lessons. In grade 9, science is scheduled for five periods. For those youngsters who proceed at a slower pace, five periods per week are recommended during the entire three years. The additional period is a laboratory period which will lend reinforcement and should enable the pupils to attain the same level of understanding as those who proceed at a faster pace. The greatest impact is made where there is direct involvement by the students; therefore, laboratory lessons are included in each unit.

4. CRITICAL THINKING. Emphasis is placed upon science as a method of thinking, of investigation, and of operation. To implement these aspects, significant scientific concepts have been selected for the understanding of the nature and structure, and the interrelationships of the sciences. The selective process stresses the need for sufficient classroom time and opportunities for mature reflection. To this end, therefore, the total content has been limited to enable the teacher to implement the goals of science education. There is an emphasis on demonstration and direct pupil experiences instead of reliance on descriptive presentation.

Format

Because of the objectives and innovations of the present course of study, material is presented in a distinctive format. Among its special features are:

Sequential units in each of four science areas
Division of each unit into complete lessons
Outcomes for each lesson
Direct reference to interrelationships among the sciences as they occur in the development of the lessons
Logically developed classroom lessons with specific content, methodology, and techniques
Designated laboratory lessons including explanatory notes for the teacher and worksheets for the pupils
Enrichment materials, such as assignments, questions, reports, and projects.

Items in italicized form, such as this, indicate material to meet the needs of highly oriented science students.

The format also provides the framework for the two basic types of science lessons: the classroom recitation and the laboratory lesson requiring direct student involvement. Both are described in the sections that follow.

The Class Lesson

To help the inexperienced teacher and the one whose area of specialization does not coincide with that of the unit, each lesson has been worked out in detail to include not only methodology, techniques, content, and outcomes, but also inductive development, where possible, and connections with lessons that precede and follow. Because so much of the burden of lesson planning is obviated by this approach, more time will be available for the many demonstrations and other multisensory experiences.

Each lesson has been numbered sequentially and tailored to fit the standard forty-minute period. The lessons include the aim, motivation, development, and terminal summary plus specific techniques — demonstrations, discussions, lectures, reports, seminars, reviews, and individual laboratory work of short duration.

Lessons using thought-provoking questions and demonstrations foster an inquiring attitude and stimulate a scientific atmosphere in the classroom. Experience shows that short question periods at the start and end of lessons are highly effective.

Since reporting is an important pupil activity, the teacher should acquaint the pupils with reliable sources of information and with the proper form, content, and structure of a report. Preferably, reports should be presented orally and not read. The class should evaluate reports on the basis of such criteria as clarity, interest, completeness, and use of illustrative material. An evaluation chart, prominently displayed, containing a list of selected criteria is an invaluable aid.

Finally, lessons in this bulletin are not intended as a substitute for individual lesson planning. Lesson plans should be adapted to the capability and personality of the individual teacher and geared to meet the specific needs of the students in a given class.

The Laboratory Lesson

Individual laboratory lessons are effective means of inculcating scientific attitudes, procedures, and modes of thinking. Consequently, pupils should be given the opportunity of planning the laboratory exercises instead of being directed step by step. After planning, pupils should be permitted initiative to perform the experiments. This the present course of study aims to do.

However, for successful planning, the teacher must first provide the required background techniques and information. In addition, he must acquaint himself and the pupils with the contents of the Board of Education booklet, "For Greater Safety in Science Teaching," since safety instruction is necessary in laboratory work which allows freedom to children.

Approximately one-quarter of the periods in the units (six single laboratory lessons) are set aside for laboratory work. Classes programmed for five periods per week have six additional laboratory lessons.

The laboratory lessons contain explanatory notes to the teacher and worksheets for the student. Initially, the worksheets include detailed step-by-step procedures, which later give way to less detailed problem-solving instructions. Not all of the laboratory lessons are of the problem-solving variety; some offer techniques or skills, while others teach concepts step by step.

The laboratory lesson is divided into three parts: the introductory or preparatory period, the work or laboratory period, and the discussion period. During the introductory period, materials should be distibuted quietly on trays by the laboratory specialist, and pupils should be given technical information if necessary. Meanwhile, the teacher should have slower pupils consider the problem and suggest possible methods for its solution. For the laboratory period, the class should be divided into groups of 2-4 pupils, depending upon the availability of equipment and materials. It is suggested that pupils retain their original groups and select a group leader responsible for taking and returning equipment. Pupils should be instructed to work together, to discuss and rotate tasks, and to call upon the teacher for needed help. It is essential that normal classroom order be maintained during the laboratory interval so that pupils may hear instructions.

It is also suggested that the teacher and laboratory specialist circulate among the pupils to encourage and assist. After a short cleanup and collection, time should be allowed for the discussion of procedures, observations, data, conclusions, and for answering questions. Every good laboratory session points up the many new problems that may lead to fruitful investigation.

The additional laboratory sessions for the inner-city child will surely prove highly productive by providing a larger concrete base for the understanding of the scientific principles that constitute the required science program.

It cannot be overemphasized that if the class is properly trained in laboratory decorum and responsibility, the laboratory work will proceed without difficulty and with much profit. To this end, the teacher must begin the proper training of pupils during the very first laboratory period.

Every pupil should be required to keep a science notebook with a laboratory section in which to record his data, observations, conclusions, and answers to the summary questions for each laboratory lesson. If he is encouraged to see new problems as he analyzes the data, he will suggest hypotheses for their solution which may become the bases for additional experimentation, projects, and laboratory work.

HOW TO USE THIS BULLETIN

Science: Grade 8 consists of four units. Each unit is selected from a major science area — chemistry, physics, biology, and earth science. Each unit consists of some thirty lessons. Approximately eighteen of these lessons may be classified as classroom lessons. The remaining twelve lessons of the unit are laboratory lessons.

Classes meeting four periods a week study eighteen classroom lessons and six of the twelve laboratory lessons in each unit. For each classroom lesson, the basic learnings for all pupils are indicated by regular type. Those items in italicized type are for highly oriented science students. The six laboratory lessons *not* marked with an asterisk are for all students. The six laboratory lessons marked with an asterisk are only for those students programmed for five periods a week in science.

Classes meeting five periods a week study eighteen classroom lessons and all twelve laboratory lessons in each unit. For each classroom lesson, only the basic learnings are indicated by regular type.

The inexperienced teacher and those teachers who may not be too familiar with all the four science areas should follow the bulletin suggestions closely.

At the end of each unit are suggested teacher references, pupil references, and enrichment activities such as suggested pupil projects, trips, and pupil research projects. Sample questions for multiple choice, completion, matching, essay, and reasoning are also included.

Unit I

CHEMISTRY

Liquid Solutions

Suspensions and Emulsions

Ionization

Air Pollution

IMPORTANT NOTE TO THE TEACHER

The sections of the text which are printed in italics (the type used in this note) are intended as enrichment material.

LIQUID SOLUTIONS

Suggested Lessons and Procedures

1. WHAT HAPPENS WHEN WE MIX DIFFERENT SUBSTANCES WITH WATER?

Outcomes

- Some solids, liquids, and gases mix evenly with water.
- Such mixtures are called homogeneous mixtures.
- A homogeneous mixture is called a solution.
- When a solid or a gas dissolves, we say it is soluble.
- When a liquid dissolves, we say it is miscible.
- The dissolved substance is called the solute.
- The substance in which it dissolves is called the solvent.
- *In solution, solutes are molecular in size.*
- *Solutions are clear (have clarity).*
- *Solutions are transparent.*

Motivation

Ask the class what happens when we put sugar in coffee. In what way is the coffee changed? What happens to the sugar?

Development

1. Display 2 beakers of water, an unopened bottle of club soda, potassium permanganate, rubbing alcohol, and a balloon.

2. a. Dissolve ½ teaspoon potassium permanganate in beaker #1.
   b. Ask the pupils to examine the mixture.
   c. Establish with the class that the potassium permanganate spread evenly through the water, making a *homogeneous* mixture.
   d. Elicit the generalization that solids may dissolve in water to form a *solution*.
   e. Point out that the potassium permanganate (the substance that dissolves) is called the *solute*. The water (the substance in which it dissolves) is called the *solvent*.
   f. Challenge the pupils to explain why grains of potassium permanganate cannot be seen in solution. Guide the pupils to understand that when a substance dissolves, it is broken down into molecular size.

3. a. Open the bottle of alcohol and have several pupils identify it by wafting it in their direction.
   b. Mix the alcohol with the water in beaker #2.
   c. Ask the pupils if they can distinguish the alcohol from the water in the beaker.
   d. Elicit the generalization that liquids may dissolve (be *miscible*) in water to form a solution.

4. a. Have the pupils examine the unopened bottle of club soda for the presence of bubbles.
   b. Gently remove the cap and attach a balloon to the mouth of the bottle.
   c. Hold your thumb on the mouth of the bottle, shake the bottle, and set it on the table.
   d. As the pupils observe the inflating balloon, establish the fact that the gas which is flowing into the balloon was originally evenly distributed throughout the water.
   e. Elicit the generalization that gases may be dissolved in water to form a solution.

5. Demonstrate the following: Add a pinch of sodium chloride and potassium dichromate to different beakers of water. Have the pupils note the resulting color and clarity of the liquid in each beaker.

6. Use a flashlight to demonstrate transparency of solutions.

Summary

1. Liquid solutions are homogeneous mixtures of __________, __________ or __________ with water.
2. An example of a solid which dissolves in water is __________.
3. An example of a liquid which dissolves in water is __________.
4. An example of a gas which dissolves in water is __________.
5. The substance which dissolves is called the __________ and the liquid in which it dissolves is called the __________.
6. When a liquid dissolves in water, it is said to be __________.
7. *In solution, the solute is of __________ size.*
8. *Solutions are clear because __________.*

Homework

1. Is milk a solution? Explain.
2. Is orange juice which has been standing a solution? Explain.
3. Mix lemon juice with water and let it stand. What happens? Is this a solution?
4. Where does a fish get its oxygen?
5. Fill a glass with tap water. Examine the water and describe it. Allow the glass to stand for 15 minutes. Examine the water again and describe what you see.

Materials

2 beakers ½ filled with water
Bottle of club soda (unopened)
Potassium permanganate
Rubbing alcohol
Balloon
Glass stirring rod

3 beakers ½ filled with water
Samples of sodium chloride and potassium dichromate
Flashlight

2. CAN SUBSTANCES WHICH WILL NOT DISSOLVE IN WATER BE DISSOLVED IN OTHER LIQUIDS?

Outcomes

- Some solids and liquids will not dissolve in water.
- Other liquids may be used as solvents in place of water.
- Solvents are selective.
- Solvents serve many useful purposes.
- *Energy changes occur during the process of solution.*

Motivation

Place a dab of nail polish on the fingernail of a volunteer and ask the pupil to remove it with water. Ask pupils to suggest a substance which will dissolve the polish. Identify the substance as acetone. Demonstrate.

Development

1. Set up two 100 cc graduated cylinders. Fill one ½ full of alcohol and the other ½ full of water. Add ½ spoonful (use plastic spoon) of iodine crystals to each and stir.
   CAUTION: Do not touch the iodine crystals with your hands.
2. Direct pupils to observe what happens in each of the cylinders.
3. Lead pupils to the conclusion that iodine will not dissolve in water, but it will dissolve in alcohol. Therefore, alcohol may be used as a solvent.
4. Set up three 100 cc graduated cylinders. Fill one ½ full of water. Fill another ½ full of alcohol. Fill the third ½ full of turpentine. Direct pupils to observe what happens when you put 3 cc of linseed oil into each cylinder and stir.
5. Lead pupils to conclude that linseed oil is miscible with turpentine. Therefore, turpentine may be used as a solvent.
6. Help pupils to understand that there are many solvents and that solvents are selective. Refer to demonstration of iodine in water and iodine in alcohol to reinforce this concept.

6a. Energy changes occur when a solute goes into solution. When the process is endothermic, the temperature of the solution is lowered. When the process is exothermic, the temperature of the solution is raised. Demonstrate solution of NH_4Cl in water (endothermic).

7. Point out several common solvents within the pupils' daily experience such as: tincture of iodine (tincture means alcohol solvent), oil paint (containing linseed oil) thinned with turpentine, "Perk" (tetrachloroethylene, used as a cleaning solution to dissolve grease in clothing), acetone (a nail polish remover).

Summary

1. Have pupils set up and complete the following chart:

MIXTURE	SOLUTION FORMED?	SOLUTE	SOLVENT
Water & iodine			
Alcohol & iodine			
Water & linseed oil			
Alcohol & linseed oil			
Turpentine & linseed oil			

2. Will water dissolve everything? Explain.
3. Which other liquids may be used as solvents?
4. Alcohol may be used to dissolve ____________ but not to dissolve ____________.
5. What is the importance of solvents in our daily lives?
6. *What kind of changes take place when a solute goes into solution?*

Homework

1. Where do we find an iodine solution in the home? What is the solvent?
2. Set up three glasses. Fill the first ½ full of water, the second ½ full of rubbing alcohol and the third ½ full of cooking oil. To each glass, add a ½ teaspoon of table salt and stir. Write your observations.

Materials

Nail polish
Nail polish remover (acetone)
Five 100 cc graduated cylinders
Alcohol
Iodine crystals
Turpentine
Linseed oil
Stirring rod (glass)

3. WHAT CONDITIONS WILL CHANGE THE TIME IT TAKES FOR A SOLUTE TO DISSOLVE?

LABORATORY LESSON

Outcomes

- Small particles dissolve more rapidly than large particles.
- Stirring makes particles dissolve faster.
- Heating makes particles dissolve faster.
- *Rate of solution depends on the surface area of the particles.*

Motivation

To a cup of cold tea add two cubes of sugar, sip, and announce that the tea is not sweet. Ask why this is so. Elicit that the sugar has not yet dissolved. Ask for suggestions to speed up the solution of the sugar.

Development

1. Distribute materials to each group of pupils.
2. Teacher should heat water and distribute it to groups as needed.
3. *Have pupils break crystals into smaller ones before grinding. Elicit that the smaller the pieces, the larger is the exposed surface.*

   Increased surface area increases solubility.
4. *With some groups, it would be advisable to include the quantitative measurement of time. Have pupils record time at beginning and end of each experiment.*

Homework

1. Take two lollypops. Place each one in a glass of water. Stir with one of the lollypops. Which one gets smaller faster?

2. What other ways could you use to get one lollypop to dissolve faster?

3. *Can you think of an experiment which will show which one of the 3 methods taken up in the laboratory lesson will prove most effective? Try it and report your findings.*

Materials

Cup of tea
Cubes of sugar
500 ml beaker
Tripod
Wire gauze
Bunsen burner
Asbestos glove

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 3

Problem: How can we make a solute dissolve rapidly?

Materials

Six 50 ml beakers (or test tubes)
2 stirring rods
Copper sulfate — chunks
Mortar and pestle
Paper towel

Procedure and Observations

1. Mark each beaker with a number from 1 through 6.
2. Fill beakers #1 through #5 half full with cold water.
3. Take two pieces of copper sulfate of about equal size. Place one piece in beaker #1 and the other in beaker #2. Stir both. Does one piece dissolve faster than the other?____________________.
4. Remove the piece of copper sulfate from beaker #2 and dry it with a paper towel. Place it in the mortar and grind it to a powder with the pestle.
5. Place the powder into beaker #2 and again stir both beakers for the count of 10. Which dissolved faster — the powdered or piece of copper sulfate? ____________________.
6. Grind several pieces of copper sulfate to a powder in the mortar. Divide the powder into two portions of about equal amounts. Place one portion in beaker #3 and the other portion in beaker #4. Stir beaker #4. In which beaker does the copper sulfate dissolve faster?____________________.
7. Again grind several pieces of copper sulfate and divide the powder into two portions. Ask your teacher to put hot water into beaker #6. Place one portion of the copper sulfate powder into beaker #5 and the other portion

into beaker #6. Do not stir. Did the powder dissolve faster in hot water or cold water?____________________.

8. Fill in the following chart:

METHOD	DISSOLVES (FASTER OR SLOWER)
Make smaller pieces	
Keep larger pieces	
Stirring	
No stirring	
Heating solvent	
Not heating solvent	

Conclusion

These laboratory experiments have shown that ____________________________

____

Application

List three ways in which you use this knowledge at home.

____

____

4. HOW MUCH SOLUTE CAN BE DISSOLVED IN A DEFINITE AMOUNT OF SOLVENT?

Outcomes

- Solutions differ from one another because of the amount of solute used (in addition to the type of solvent and solute).
- A solution may be dilute.
- A solution may be concentrated.
- A solution may be saturated.
- *Concentration may be expressed as percent.*
- *Concentration may be expressed as normality or molarity.*

Motivation

Set up 2 beakers filled with hot water. Dissolve 1/4 teaspoon of instant coffee in beaker #1 and 2 teaspoons of instant coffee in beaker #2. Ask the pupils to examine the beakers and explain the difference in appearance.

Development

1. Review the terms solute, solvent, and solution.
2. Set up four 150 cc beakers. Add 100 cc hot water to each beaker.
3. Challenge pupils to suggest how to make up four different solutions of copper sulfate.
4. Following the pupils' suggestions, add different amounts of powdered copper sulfate to each beaker and stir. Arrange the beakers on the table in the order of their concentrations.
5. Ask the pupils to describe the solutions.
6. By asking the questions, "Which solution has the least solute? Which has the most solute?" establish the fact that these solutions differ in color due to the amount of solute used.
7. Elicit the fact that in a colorless solution such as sugar in water, it is possible to detect the amounts of solute by tasting.
8. Identify the weakest solution as *dilute.*
9. Identify the strongest solution as *concentrated.*

9a. *Explain that scientists do not rely on color or taste to determine strengths of solutions.*

b. *Display bottles of solutions whose concentrations are labelled in percentages.*

NOTE: *The explanation of molarity and normality should not be attempted at this time.*

c. *Demonstrate how to prepare various concentrations (by weight) of solutions, such as: 5% (5 grams in 95 cc water), 10% (10 grams in 90 cc water), 60% (60 grams in 40 cc water).*

NOTE: *One gram of water has a volume of one milliliter.*

10. Using the most concentrated solution, ask the pupils, "Can we add

more copper sulfate to this beaker?" "How much more can we add?" Add copper sulphate to the beaker until no more will dissolve. Identify this as a *saturated* solution. Ask "How can we tell this is a saturated solution?"

10a. Add approximately 40 gms of copper sulfate to 100 cc water to make a saturated solution.

Ask, "Is it possible to dissolve more copper sulfate in this amount of water?" Discuss additional heating.

Summary

1. How can we tell which solution contains more solute?
2. A solution which contains a small amount of solute is called ____________________.
3. The more solute a solution contains, the more____________________ it is.
4. When a solution contains as much dissolved solute as it can hold, it is a__________________solution.
5. *How can we make 100 cc of a 50% solution of copper sulphate in water?*
6. *How much alcohol would you add to 75 cc of water to make a 25% solution?*

Homework

1. Is salt water a mixture or a compound?
2. Why did we use powdered copper sulphate?
3. Why did we use warm water?
4. Set up three cups of coffee and a container of sugar. Make a dilute solution of sugar in the first cup, a concentrated solution in the second cup, and a saturated solution in the third cup. Write out the method you used to make the solutions and describe how you could test to show that the solutions were different.
5. *How many grams of salt are required to make 100 grams of a 4% solution?*

6. *How many grams of water should you add to 10 grams of sugar to make a 10% solution?*

Materials

Six 150 cc beakers
Hot water
Instant coffee
Powdered copper sulphate
Spatula
Glass stirring rod
Ring stand, clamp gauge
Alcohol lamp or bunsen burner

Balance
Filter paper

5. *WHY ARE LIQUID SOLUTIONS CLEAR?

LABORATORY LESSON

Outcomes

- In a solution, the particles of the solute and the solvent are too small to be seen.
- If the particles can be seen, it is not a solution.
- A solution is clear and transparent

Development

1. Distribute materials to each group of pupils.
2. Have pupils proceed with laboratory work.
3. At the end of the laboratory procedures, take one rack of test tubes from one of the groups. Shine a flashlight through the test tubes. Have the pupils recognize that those which contain solutions are clear and *transparent*.

Summary

A liquid solution is clear and transparent. Use the questions on the Worksheet to reinforce these concepts.

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* *Only for classes programmed for five periods.*

LABORATORY WORKSHEET — CHEMISTRY: LESSON 5

Problem: Why are liquid solutions clear?

Materials

6 test tubes	Test tube rack
Cube of sugar (small)	Test tube holder
Small amount of flour	Alcohol lamp
Vinegar	Glass stirring rod
Corn oil	

Procedure and Observations

1. Fill 6 test tubes half full of water. Number the test tubes 1 through 6.
2. Add the sugar cube to test tube #1. Stir. What happened to the sugar? ____________________.
3. Add a small amount of flour to test tube #2. Stir. What happened to the flour?____________________.
4. Pour 1 inch of vinegar into test tube #3. Stir. What does the mixture look like?____________________.
   Can you find the vinegar in the water?____________________.
5. Pour 1 inch of corn oil into test tube #4. Stir. Describe what you see in test tube #4____________________.
   Can you find the corn oil in the water?____________________.
6. Carefully heat the water in test tube #5 until it starts to boil. Make sure you point the test tube away from yourself and your neighbors. Set the test tube in the rack to cool.
7. Taste the water in test tube #5 and test tube #6. Is there any difference in the taste?____________________.
   What do you think caused the difference in the taste?____________________.
8. Examine the six test tubes. Fill in the information on this chart:

TEST TUBE #	SOLVENT	SOLUTE	CLEAR OR CLOUDY?	SOLUTION OR NOT A SOLUTION?
1.				
2.				
3.				
4.				
5.				
6.				

In which test tubes did the solute sink to the bottom? ____________.

Can you see the solute in the other test tubes? ____________.
Why? ____________.

Conclusions

1. In a solution, the particles of solute are ____________ (small, large).
2. In a solution, the particles ____________ (can, cannot) be seen.
3. If the particles can be seen, it ____________ (is, is not) a solution.
4. A solution is always ____________ (clear, cloudy).
5. Light passes through a solution. This proves that a solution is ____________.

Homework

Try the following experiments at home, using only a small quantity of solute and stirring. Put your results on the following chart:

Solvent	Solute	Clear or cloudy	Solution or no solution
Water	salt		
Water	bread crumbs		
Water	rubbing alcohol		

6. HOW CAN WE FIND THE TEMPERATURES AT WHICH LIQUIDS FREEZE?

Outcomes

- Pure water freezes at 0°C (32°F).
  Note: °C should be read as "degrees Celsius."
- To freeze water we must remove heat (energy).
- The mixture of ice and water remains at 0°C until all the water is frozen.
- Other liquids show the same property except that their freezing points are different.
- *Identify the heat energy that is removed to change a liquid to a solid when the temperature is constant, as the* heat of fusion.

Motivation

Ask pupils how they would make ice cubes. Elicit that the temperature around the tray must be a freezing temperature.

Development

Note: The following demonstrations may be done with pupil volunteers.

1. To a 500 ml beaker containing 100 ml of water, add 3 heaping tablespoons of rock salt and stir. Add 6 ice cubes and continue stirring until the temperature of the mixture is below 0°C.
2. Stand a 100 ml beaker containing 25 ml of distilled water in the mixture.
3. Have pupils read and record the temperature when you begin and at one minute intervals. Continue taking readings until you have 3 or 4 readings of the same temperature.
4. Record your results on a chalkboard chart such as:

TIME (MIN.)	TEMPERATURE (°C)
0	
1	
2	
3	

5. Between readings, stir the water in the small beaker. Ask, "Where is the heat of the water in the small beaker going?" Lead the pupils to understand that when a liquid cools it loses heat to something that is colder than itself.
6. When ice crystals have formed in the small beaker and 3 or 4 readings of constant temperature have been made, elicit that water freezes at a definite temperature and that the mixture remains at the freezing point until all the water is frozen.

6a. Challenge pupils to determine whether heat is removed from the ice and water mixture if there is no change in temperature. Lead them to understand that heat energy must be removed to change a liquid to a solid without change of temperature. Identify this heat as heat of fusion.

6b. Display a test tube previously prepared with 10 ml of water and is frozen. Elicit that to "unfreeze" the water, the heat of fusion is returned. Briefly review the meaning of calorie and tell the pupils that the heat of fusion *for water is 80 calories per gram.*

6c. Distribute graph paper and have the pupils draw a line graph of the temperature time readings using the y-axis for the temperature and the x-axis for the time. Help them to understand that the downward slope of the graph means that the water is losing heat and its temperature is falling. The horizontal portion means that ice is forming and heat of fusion *is being removed.*

7. Repeat the demonstration to find the freezing point of alcohol. Use dry ice instead of the salt and ice water mixture. Ask why dry ice is being used.

   CAUTION: Do not permit pupil to handle dry ice. Use tongs.

   NOTE: Alcohol freezes below 0°C. Use a thermometer which records temperatures to −20°C.

8. Help pupils to understand that liquids have different freezing points and that they freeze when enough heat is removed.

Summary

1. Water freezes at ____________°C.
2. Alcohol freezes at ____________°C.
3. Different liquids have different ____________ points.
4. When a liquid cools ____________ is being removed.
5. A mixture of ice and water remains at 0°C until ____________.
6. *The heat lost during the period of constant temperature during freezing is called* ____________.
7. *When ice melts, the* heat of fusion *is* ____________.

Homework

1. Take two ice cube trays or other containers which fit into the freezing part of the refrigerator. Into one tray pour a cup of water and into the other tray pour a cup of vinegar. Examine the trays every half hour. Which tray froze solid first? Do all liquids have very different freezing points?

2. *Plot a line graph of the temperature-time readings of the freezing of alcohol.*
3. *Explain the meaning of the downward slope and the leveling of the line.*
4. *How many calories must be removed to change 3 grams of water to ice at 0°C?*

Materials

500 ml beaker
100 ml beaker
Rock salt
Tablespoon
Ice cubes
Alcohol
Dry ice (small pieces)
Stirrer
Tongs

Graph paper

7. HOW DOES THE AMOUNT OF SOLUTE CHANGE THE FREEZING POINT OF WATER?

Outcomes

- Water freezes at a lower temperature than 0°C when a solute is added.
- The greater the amount of solute dissolved, the lower will be the freezing point.
- Tap water contains dissolved solutes.
- *For each formula weight of salt in solution (one liter), the freezing point of water is lowered about 4°C.*

Motivation

Recall that in the previous lesson, salt was added to the freezing mixture. Ask, "Was the salt water and ice mixture colder than the water in the test tube?" "How can you tell?"

Development

Note: Pupils may be called upon to assist you with the demonstrations.

1. Weigh three samples of sodium chloride in the following amounts — 5.8, 11.6, and 17.4 grams. Dissolve each sample in 50 ml of distilled water in 100 ml beakers.

1a. *Explain the term* formula weight. *Show that the formula weight of sodium chloride is 58. Tell the pupils that a* molar *solution is made by dissolving one formula weight in grams in 1000 grams of water (1 ml of water weighs one gram). Explain that by taking 5.8, 11.6, and 17.4 grams in 100 ml of water we have concentrations of 1 molar, 2 molar, and 3 molar solutions.*

2. Prepare a trough with crushed dry ice.
   CAUTION: Do not permit pupils to handle dry ice.

3. Place each beaker in turn in the freezing mixture and determine its freezing point. It is important to keep the mixture stirred. Record the data on a chalkboard chart.

4. Have the pupils compare the freezing point of pure water to the freezing point of the salt water solution. Elicit that when a solute is dissolved in water, the water freezes at a lower temperature.

4a. *Distribute graph paper and have the pupils draw a graph of the lowering of the freezing point with addition of solute, using molar concentrations on the y-axis and freezing point on the x-axis. Lower concentrations should be higher on the y-axis to show a "drop." Call attention to the regular drop in freezing point for each molar increase in concentration.*

5. Ask, "What effect does adding more solute have on the freezing point?" Help pupils to understand that as more solute is dissolved the water freezes at lower temperatures.

6. Ask, "How can we find out whether tap water has any dissolved solutes?"
   Repeat the demonstration, using tap water. Elicit that tap water contains dissolved solutes. Stress that this demonstration does not show which solutes are dissolved in water.

Summary

1. Water freezes at a (higher, lower) __________ temperature when a solute is added.

2. The freezing point of water is (higher, lower) __________ if more solute is dissolved.

3. Drinking water (from the tap) (does, doesn't) ____________ contain dissolved solutes.
4. *The sum of the atomic weights of all the atoms in a compound is called ____________.*
5. *A molar solution contains one ____________ of solute in ____________ of water.*
6. *For each formula weight of salt dissolved, the freezing point of water is lowered ____________ °C.*

Homework

1. Why is salt thrown on ice in the winter time?
2. Why does adding antifreeze to a car radiator prevent the water from freezing?
3. Take two ice cube trays. Add a teaspoonful of salt to a glass of water and stir. Empty a glass of tap water into the second tray. Place both trays in the freezer, and examine them every 15 minutes. Which froze first? How can you explain your result?
4. *Draw a line graph of the freezing of tap water. What does the steepness of the curve show? What does the horizontal part of the curve show? Compare this graph to the one you drew in class.*

Materials

Trough
Dry ice (crushed)
Stirrer
Triple beam balance
Sodium chloride
Three 100 ml beakers

Graph paper

8. WHAT HAPPENS TO A LIQUID AS ITS TEMPERATURE RISES?

Outcomes

- Heating causes the formation of bubbles at the bottom of the container.
- A liquid is said to be boiling when the bubbles move upwards.

- The temperature at which boiling starts is called the boiling point.
- The continued heating, after the boiling point has been reached, does not raise temperature, but accelerates evaporation.
- Liquids boil at specific temperatures.
- *The heat which is absorbed after the boiling point has been reached, is called the* heat of vaporization.

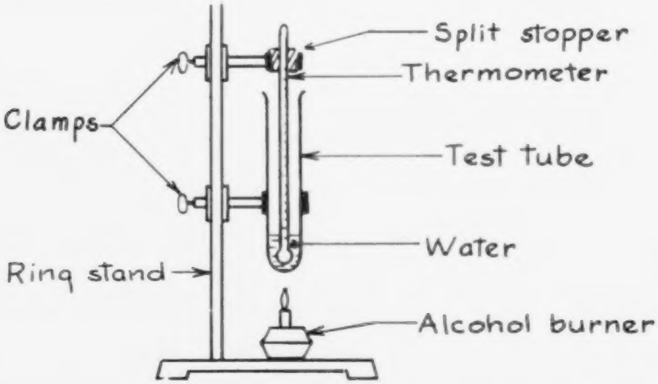
Motivation

Ask the class, "What causes water to boil?" Elicit the fact that heat must be added.

By asking, "How do we know when water is boiling?" establish that escaping bubbles indicate boiling.

Development

1. Set up the equipment as shown:



The bulb end of the thermometer should be in the water, but should not be touching the bottom or sides of the test tube. The split stopper is held in place by the clamp, but should not hide the numbers on the thermometer.

2. While the water is heating, ask one pupil to read the thermometer at 2-minute intervals. Have another pupil record the temperature on the following chart on the board:

TIME (MIN.)	TEMPERATURE (°C)
0	
2	
4	
6	
8	
10	

3. From their observation of the bubbles in the water, ask the pupils to identify the temperature at which the water starts to boil. Place a check on the board chart next to this reading.

4. Continue reading the temperature for several minutes after boiling starts. Ask:
   a. "Is there any additional change in temperature?"
   b. "What is coming out of the water at this time?"
   c. "What does additional heating do to the water?" Define the term *evaporation*.

4a. *Distribute graph paper. Using the data on the chalkboard, have the pupils draw the boiling point curve. The level portion on the boiling point curve is similar to the level portion on the freezing point curve. Each indicates a change of state. On the boiling point curve, this line represents the time during which heat is absorbed without a corresponding change in temperature. This heat is called the* heat of vaporization. *For each gram of water at 100°C, the* heat of vaporization *is 540 calories. Review the definition of a* calorie.

5. Repeat the demonstration to find the boiling point of acetic acid.

   NOTE: Glacial acetic acid boils at 118°C. (Avoid putting your face too close to the liquid.)

6. Compare the two charts and elicit the fact that acetic acid boils at a different temperature from water. Arrive at the generalization that a given liquid boils at a specific temperature.

6a. *Ask the class, "Is the* heat of vaporization *the same for acetic acid as it is for water?" "Which requires more calories, acetic acid or water?"*

7. Review the fact that 100°C is equivalent to 212°F.

Summary

1. How did you know when the liquids started to boil?
2. What was added to the liquids to cause them to boil?
3. How long did it take for the water to boil? The acetic acid? Which boiled faster? Which liquid, water or acetic acid, required more heat to make it boil?
4. What is the boiling point of water in °C? °F?
5. What is the boiling point of acetic acid in °C?
6. Does acetic acid boil at a higher or lower temperature than water?
7. What happens if you continue heating a liquid after it reaches its boiling point?
8. *What is meant by* heat of vaporization?
9. *Which has a higher* heat of vaporization, *acetic acid or water? How do you know?*

Homework

1. Place ½ cup of tap water in a pan and heat it to boiling. Record the time it takes. Pour out the water.

   Place 1 cup of tap water in another pan and heat it to boiling on the same flame. Record the time.

   a. Does the ½ cup of water boil in the same time as the whole cup? Explain.

2. Place ½ cup of tap water in one pan and ½ cup of tea in another pan. Heat both pans, keeping both flames at the same height. Record the time it takes for each liquid to boil. Does tea have the same boiling point as water? Explain.
3. *Make a graph showing the boiling point curve for acetic acid.*

Materials

8″ test tube containing 10 ml of water
Celsius thermometer
2 clamps
Ring stand
One-hole rubber stopper (cut out ¼″ wedge)
Alcohol burner
10 ml acetic acid

Graph paper

9. HOW DOES THE ADDITION OF SOLUTE CHANGE THE BOILING POINT OF WATER?

LABORATORY LESSON

Outcomes

- Dissolved solids raise the boiling point of water.
- For a given substance, the more solute dissolved in a definite amount of water, the higher the boiling point.

Motivation

Refer to the homework assignment of the previous lesson. Ask the class, "Did the tea boil in the same time as the water?" "Which required more heat to boil, tea or water?" "Why?"

Development

1. Distribute the materials to each group.

NOTE: Make up the following solutions in advance. Each group will work with two solutions.
Solution A — 18 grams of NaCl to 100 ml water.
Solution B — 36 grams of NaCl to 100 ml water.

2. Review the effect of dissolved solutes on the freezing point of water (Lesson 7).
3. Proceed to the laboratory lesson. Check pupils' setups before permitting them to start. On the board, write each group's results. Then compare the results.
4. Summarize by referring to the conclusions of the experiments.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 9

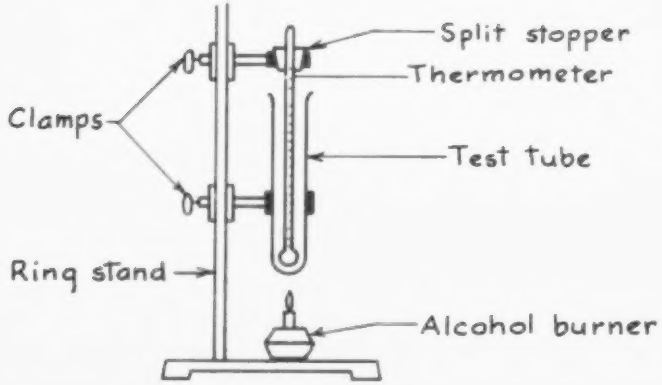
Problem: How does a solute affect the boiling temperature of the water?

Materials

8" test tube containing 10 ml Solution A
8" test tube containing 10 ml Solution B
2 Celsius thermometers
4 clamps
2 split stoppers
2 ring stands
2 alcohol burners

Procedures and Observations

1. Set up the apparatus as shown below.



The bulb end of the thermometers should be in the solutions but not toucl ing the bottom or sides of the test tubes. The split stoppers should not hid the numbers on the thermometers.

2. Have your teacher check the setups.

3. Heat the solutions until they boil. Do not put your face or hands over the open test tubes. Make sure the test tubes are not pointed toward anyone.

4. Complete the information on the following table:

SOLUTION	COMPOSITION OF SOLUTION	BOILING POINT
Water		100°C
A		
B		

Conclusions

1. Solution of solids have a ________________ (lower, higher) boiling point than plain water.

2. The boiling point of Solution B (36 grams of salt in 100 ml of water was ________________ (lower, higher) than the boiling point of Solution A. (18 grams of salt in 100 ml of water).

3. How does a solute change the boiling point of water? ________________.

4. How does adding more solute change the boiling point of a solution?
____

Homework

1. Why could you get a worse burn from boiling soup than from boiling water?
2. Take two pans of equal size. Add 1 cup of water to the first pan and 1 cup of water plus 2 teaspoons of salt to the second pan. Place both pans on the stove and bring them to a boil. Make sure both flames are of the same height. When the water is boiling, add 6 elbow macaroni to each pan. Continue to boil for 5 minutes. Remove the macaroni from the pans and permit them to cool. Taste the macaroni. Which macaroni is softer, that which is boiled in plain water or that which is boiled in salt water? Why?

10. *HOW CAN GRAPHS BE USED TO SHOW THE CHANGES IN TEMPERATURE WHEN WE FREEZE WATER AND WHEN WE BOIL WATER?

Outcome

- Data from a table can be plotted on a line graph. The graph can then be used to interpret and show relationships.

  NOTE: See explanation at end of lesson.

Motivation

Display a simple line graph. Show how a line graph can be used. Explain how this one was made. Tell the pupils they are going to graph the information they collected in Lessons 6 and 8 and then "read" the information.

Development

1. Distribute 2 sheets of graph paper and a ruler to each pupil. Advise the pupils that it is better to work on a graph in pencil.
2. Ask the pupils to take out the data tables they made for Lessons 6 and 8. For those who do not have tables, copy reasonable sets of data on the chalkboard.

** Only for classes programmed for five periods.*

3. Have the pupils copy the data from Lesson 6 on the upper right-hand portion of a sheet of graph paper. Arrange the data in the form of a table:

Time (min.)	*Temp.*
0	
2	
4	
6	
8	
10	

4. Direct the pupils to draw a vertical and a horizontal line to represent the axes. Label the vertical line, "Temperature °C" and the horizontal line, "Time, minutes." Title the graph, *Freezing Point Curve.*
5. Instruct pupils how to place dots on the graph to correspond with their data. Have pupils use a ruler to connect the dots.
6. Repeat steps #3, 4, and 5, using the data from Lesson 8. Use the second sheet of graph paper. Title the graph, *Boiling Point Curve.*

NOTES TO TEACHER:

1. Each point on the graph represents a temperature at a specific time.
2. On the freezing-point curve, the level portion of the graph represents the freezing of water. The water is being cooled but its temperature is not changing. (Heat of Fusion)
3. On the boiling-point curve, the level portion of the graph represents the changing of water into steam. The water is still being heated but its temperature is not changing. (Heat of Vaporization)
4. The level portion on the freezing-point curve is used as the "fixed" freezing point on the thermometer.
5. The level portion on the boiling-point curve is used as the "fixed" boiling point on the thermometers.

Summary

1. In the beginning, the freezing point graph slants__________ (up, down).

2. This means that the temperature of the water is__________(rising, falling).

3. In the beginning, the boiling point graph slants__________(up, down).

4. This means that the temperature of the water is__________(rising, falling).

5. The level portions of the graphs mean that the temperature is __________(constant, changing).

6. At what temperature did the water freeze?__________.

7. At what temperature did the water boil?__________.

8. What did the water change into as it froze?__________.

9. What did the water change into as it boiled?__________.

10. In freezing, water changes from the__________state to the __________state.

11. In boiling, water changes from the__________state to the __________state.

Homework

Make a graph of the data from Lesson 7. Show how the dissolved salt lowers the freezing point of water.

Materials *(for each pupil)*

2 pieces of graph paper	Ruler

11. HOW CAN WE RECOVER THE SOLUTE FROM A SOLUTION?

Outcomes

- A solute cannot be removed by filtering.
- A solute may be recovered by removing the solvent by evaporation.
- Evaporation changes a liquid into a gas. Boiling is rapid evaporation.

- *Gas solutes can be removed from solution by raising the temperature.*
- *Elicit that the more energy applied to a solution the easier the solvent molecules will leave. (Relate to the* kinetic molecular theory.)

Motivation

Display a 10% solution of copper sulfate and ask pupils to suggest ways of recovering the copper sulfate. Write the suggestions on the chalkboard and proceed first to try filtration.

Development

1. Have the pupils define *filtration*. Filter the copper sulfate solution. Ask, "Did we remove the copper sulfate from the solution?" "How do you know this?" Elicit that the particles are too small to be filtered.

2. Have the pupils define *evaporation* as a process in which a liquid changes to a gas. Have the pupils wet the backs of their hands slightly and note when it looks dry.

2a. Discuss with pupils the kinetic molecular theory. *Point out that all molecules have energy and are always in motion. This is called* kinetic energy. *Relate this to evaporation (some molecules at the surface of a liquid have enough kinetic energy to escape from the liquid; these molecules are relatively far apart and exist as a gas).*

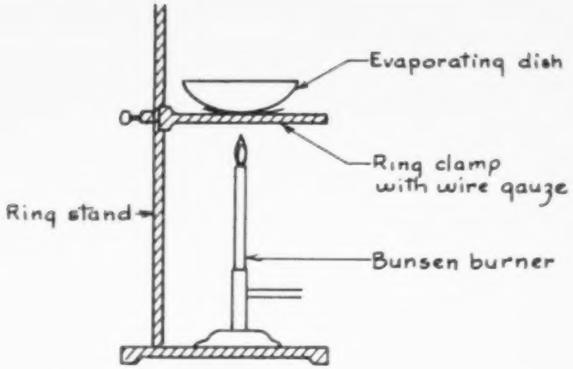
3. Boil 10 ml of water in a beaker. Have the pupils define boiling as changing of water to steam. Review:

   — the definition of boiling point
   — ask, "What is the boiling point of water?"

3a. Elicit that by heating water, its energy is increased. When the water molecules receive the energy, this heat energy is changed to kinetic energy. With more kinetic energy, many more molecules can escape from the liquid as a gas.

4. Ask, "How would boiling or evaporating a solution help to recover a solute?" Display an evaporation dish and have pupils tell why it is better than a beaker.

   Place the copper sulfate solution in an evaporating dish and heat to dryness.



Have pupils generalize that evaporating the solvent leaves the solute behind.

5. *Open and display two bottles of club soda, one at room temperature and the other cold. Have the pupils observe that in the warmer bottle the dissolved gas escapes faster. Help pupils to understand that when the temperature is higher the gas is less soluble.*

Summary

1. Can a solute be removed from a solution by filtering? Why?
2. What happens when a liquid evaporates?
3. In what way is boiling like evaporation?
4. How can we regain a solute from a solution?
5. *Explain the difference between boiling and evaporation in terms of* kinetic molecular theory.
6. *Review solubility of gases in relation to temperature.*

Homework

1. Dissolve two teaspoons of sugar in a glass of hot water. Think of a way of regaining the sugar. Do it and report on what you did.
2. Why should you take a bath or shower after swimming in the ocean?

1a. Why can't a fish live in water that was boiled and then cooled?

2a. What is powdered milk? How can you change powdered milk into regular milk? Use powdered milk to prepare a quart of milk. Does it taste the same as regular milk? Does the label on the powdered milk help to explain this?

Materials

10% copper sulfate solution	Ring stand
2 — 150 ml beakers	Wire gauze
Filter paper	Evaporating dish
Funnel	
2 bottles of club soda	*Bottle opener*

12. HOW CAN WE REMOVE THE SOLVENT FROM THE SOLUTE?

LABORATORY LESSON

Outcomes

- Heating a liquid changes it from a liquid to a gas. This is called *evaporation.*
- Cooling a gas may change it from a gas to a liquid. This is called *condensation.*
- The combined processes of evaporation and condensation is called *distillation.*
- Distillation can be used to separate a solvent from a solute.
- *Solution and distillation can be explained by the* kinetic molecular theory. *(See Lesson 11)*
- *Solutions of liquid solutes in liquid solvents can be separated by* fractional distillation.

Motivation

Recall the previous lesson on evaporation. Ask, "What happened to the water when we boiled the solution? Can you think of some way we could collect the water that boiled off?"

Set up a small beaker containing a saturated salt solution. Boil the solution. Place a clear glass plate on top of the beaker. Show the pupils the droplets of water that collect. Permit a pupil to taste the water and tell the class if it tastes salty. Ask, "What happened to the steam when it touched the glass plate?" "What happens to a gas when it is cooled?" Identify this as *condensation*. Explain that the combination of evaporation and condensation is called *distillation*.

Development

1. Proceed to the laboratory lesson.
2. Check each setup before you permit the pupils to start.
3. *After the pupils have completed the procedures, explain distillation in terms of the kinetic-molecular theory.*
4. *Ask the pupils how distillation could be used to separate a solution of a* liquid *solute in a liquid solvent. Lead the pupils to realize that a substance with a lower boiling point will boil off first. This method of separating a liquid solute from a liquid solvent is called* fractional distillation.
5. *Demonstrate, or plan a laboratory experience which permits the separation of alcohol from water. Use a Liebig condenser for this activity. Collect a small amount of alcohol and have the pupils identify it by the odor. Explain that since alcohol boils at 78° C, it evaporates first, leaving pure water behind.*
6. *A practical application is the separation of gasoline from petroleum.*

Summary

1. The process of changing a liquid into a gas is called__________.
2. When a gas is cooled, it changes into a__________. This is called __________.
3. When a liquid evaporates heat is__________(taken in, given off).
4. When a liquid condenses, heat is__________(taken in, given off).
5. The combination of evaporation and condensation is called __________.
6. Does distilled water contain any impurities? Explain.

7. *How can we explain evaporation and condensation in terms of the Kinetic-Molecular Theory?*

8. *Why is it important to know the boiling points of both the solute and the solvent before performing a distillation?*

Homework

1. Boil some tap water in a pan. Place a cool plate over the pan until some steam condenses. Taste the water on the plate. Now taste some tap water. Is there any difference in taste? Is tap water pure water? What does tap water contain besides water?
2. If you were lost at sea and the only available water was sea water, how could you make this water suitable for drinking?
3. *What is evaporated milk? How could you change evaporated milk into whole milk? Use a sample of evaporated milk and prove your hypothesis. Record your results.*

Materials

Beaker
Saturated salt solution
Alcohol
Alcohol burner
Glass plate
Liebig condenser

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 12

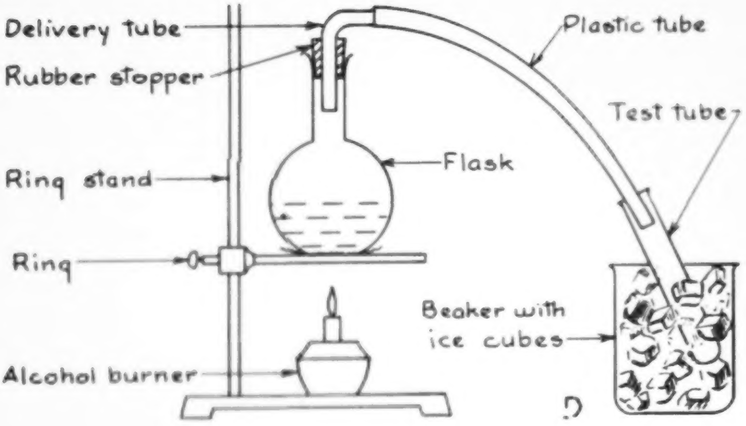
Problem: How can we separate a solvent from a solid solute?

Materials

Erlenmeyer flask ¼ filled with 1% copper sulphate solution
Glass tube right angle bend, inserted in stopper
10" plastic tubing
Ring stand, ring, wire gauze
Alcohol burner
100cc beaker, filled with ice cubes
Test tube
One-hole rubber stopper

Procedure and Observations

1. Set up the apparatus as shown in the diagram: (See next page.)
2. Ask the teacher to check your setup before lighting the alcohol burner.
3. Heat the solution for 5-10 minutes.


Delivery tube
Rubber stopper
Plastic tube
Test tube
Flask
Ring stand
Ring
Beaker with ice cubes
Alcohol burner

4. Cap the alcohol burner and remove the test tube from the beaker.
5. Why did we heat the solution? ____________.
6. What part of the solution evaporated? ____________.
7. What was left behind in the flask? ____________.
8. What state (solid, liquid, or gas) was the part that evaporated? ____________.
9. Why was the ice necessary? ____________
10. What did you find in the test tube? ____________.

Conclusions

1. To separate a liquid solvent from a solid solute we use the process of ____________.
2. If we continue to heat this solution, we will have all of the ____________ in the test tube and solid ____________ in the flask.

---

13. WHAT FORM DOES A SOLUTE HAVE WHEN THE WATER IS EVAPORATED?

Outcomes

- When a solution is evaporated, crystals of the solute remain.
- Crystals are solids with definite shapes.
- All crystals of one substance have the same shape.

- When a supersaturated solution is seeded, the solute crystallizes.
- *Crystalline structure is due to orderly arrangement of atoms.*
- *Crystallization may be used to purify a substance.*
- *Fractional crystallization may be used to remove individual solutes from a solution.*

Motivation

Ask, "What remains on the skin when salt water dries after a swim at the beach?" Elicit that the salt remains as a solid. Ask, "What does the solid look like?"

Development

1. Place a drop of sodium chloride solution on a slide. Spread the solution on the slide and demonstrate the formation of *crystals* with a microprojector.

2. Point out the regular square faces on the crystals. Ask, "If every face of the crystals is a square, what is the total shape?" Circulate calcite crystals so that the pupils may inspect the cubic structure. Elicit that the three dimensional figure is a cube.

2a. Lead the pupils to understand that the orderly structure of a crystal must be due to the orderly arrangements of its atoms.

3. Ask, "How can we get crystals without evaporating the water?" Have pupils recall the concept of *saturated* solutions. Ask, "How can we make more solute dissolve?" Elicit that as we raise the temperature of a solution more solute will dissolve. Demonstrate by making two saturated solutions of potassium nitrate. Add the potassium nitrate to 100 ml of water in a 150 ml beaker. Have pupils identify it as a *saturated solution.*

4. Heat solution #1 gently and continue adding the solid and stirring until the temperature reaches 40°C. Add solute until saturated. Then raise the temperature slightly to dissolve excess. Allow the solution to cool to the temperature of solution #2 (the control solution). Ask, "How does solution #1 differ from solution #2?" Identify solution #1 as *a supersaturated solution.*

5. Seed both solutions with crystals of potassium nitrate. Identify this as seeding. When the new crystals form in solution #1 ask,

"Which part of the solute crystallized?" Help them to understand that the crystals are the extra solute which normally would not dissolve at this lower temperature. Ask, "Why don't the crystals dissolve in the solution?" Elicit that the remaining solution is saturated.

6. *Place beaker #2 in a 500 ml beaker containing a freezing mixture of crushed ice cubes and salt. When crystals have formed, ask "Where did these crystals come from?" Heat the beaker gently to room temperature and ask, "Is the solution saturated now?" "How can we tell?" Confirm that the solution is unsaturated by dissolving more solute. Elicit that crystals form when the temperature is lowered sufficiently.*

   Explain that when the atoms of a substance crystallize from solution, they leave the impurities behind. This is a method of purifying a substance.

   When two substances are present in a solution, they may be separated by lowering the temperature. The less soluble substance will crystallize first. This process is called fractional crystallization.

Summary

1. When a solution of a solid is evaporated the____________remains.
2. Table salt crystals have the shape of a____________.
3. All the crystals of a substance have (the same, different) ____________shape(s).
4. Hot water can hold (more, less)____________solute than cold water.
5. When a solution holds more solute than it normally can at a given temperature, the solution is called a____________solution.
6. When crystals of the solute are added to a supersaturated solution, the "extra" solute forms as____________.
7. The remaining solution is (saturated, unsaturated)____________.
8. *When the temperature of a solution is lowered sufficiently, the ____________crystallizes.*
9. *When a substance crystallizes, the impurities (remain in solution, crystallize)____________.*

10. *Two substances may be removed separately from a solution by the process called__________.*

11. *The__________of a crystal are arranged in a definite order.*

Homework

1. Heat water in a small pot to slow boiling. While the water is boiling add sugar and stir. Keep adding sugar until no more dissolves. Pour the solution slowly into a glass and allow it to cool.
2. Tie a 3-inch, clean piece of string (or thread) to a toothpick. Wet the string and dip it in sugar. Hang the string in the solution with the ends of the toothpick resting on the rim of the glass. What do you observe?

   Allow the glass to stand undisturbed overnight. What do you see now? How can you explain this?
3. *If you had sugar and salt in one solution, could you separate them by evaporation? Why?*

Materials

10 ml of sodium chloride solution
Medicine dropper
Slide
Microprojector
Calcite crystals
Potassium nitrate (crystalline)

500 ml beaker
6 ice cubes

2 150 ml beakers
Ring stand
Ring clamp
Wire gauze
Stirrer
Celsius thermometer

Sodium chloride

14. *HOW CAN SEAWATER BE MADE FIT FOR DRINKING?

LABORATORY LESSON

Outcomes

- Distillation is used to purify water.

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* *Only for classes programmed for five periods.*

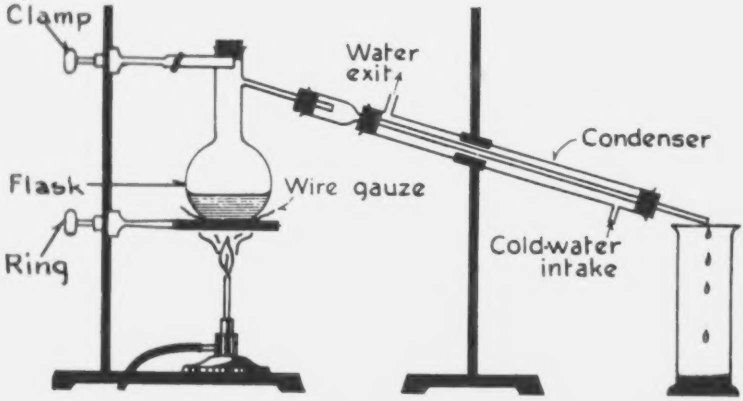
- Evaporation and condensation can be explained by the kinetic molecular theory.
- The Liebig condenser is a piece of apparatus specially made for distillation.

Motivation

Ask, "Suppose you were lost at sea without fresh water. Could you do anything to the sea water to make it fit to drink?"

Development

1. Review the distillation of the copper sulfate solution (Lesson 12).
2. Set up the Liebig condenser in advance, as shown in the diagram:



   Tell the pupils that this is a special piece of apparatus used for the purpose of distillation. Name the parts of the *condenser*.

3. Distribute the materials to the laboratory groups.
4. Have the pupils set up their distillation apparatus and compare their setups with the Liebig condenser.
5. Check the pupils' setups and start the Liebig condenser at the same time as the pupils start their distillation.
6. When the procedures are finished, compare the distillate from the

Liebig condenser with the liquid in the pupils' test tubes. Elicit the fact that the Liebig condenser does the same job as their simple setups but that it is more accurate and efficient.

7. Ask, "What happens to the molecules of a liquid when the liquid is heated?" Elicit the fact that molecules are constantly in motion and that heat makes them move faster. (This concept was learned in Grade 7, Physics.)

8. The teacher may guide discussions of evaporation and condensation in terms of the kinetic molecular theory, if time permits.

Summary

1. Use the questions on the pupils' worksheets to summarize the laboratory lesson. Then continue with the questions below.

2. When the molecules in a liquid are heated to boiling, the liquid changes into a__________(gas, liquid).

3. What happens to the molecules in a substance when it is heated? __________.

4. When molecules escape from a liquid, the process is called __________.

5. Cooling a gas changes it into a__________(solid, liquid).

6. This process is called__________.

Homework

1. Explain how you distilled water during the laboratory lesson you had in school.

2. Dissolve two teaspoonfuls of sugar in a cup of water. Taste the water. Boil the solution and place a glass plate over the top of the pan. Taste the water droplets on the plate. How does this water compare with the water in the pan? What process does this show?

Materials

Liebig condenser
Salt water

LABORATORY WORKSHEET — CHEMISTRY: LESSON 14

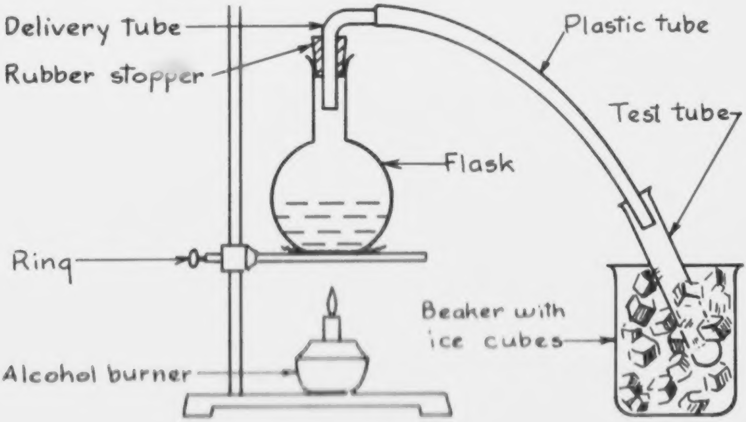
Problem: **How can seawater be made fit for drinking?**

Materials

Erlenmeyer flask ¼ filled with very warm water
5 grams of salt
One-hole rubber stopper
Glass tube (right angle bend) inserted in stopper
10" of plastic tubing
Ring stand, ring, wire gauze
Alcohol burner
100cc beaker containing ice cubes
Test tube
Glass stirring rod

Procedures and Observations

1. **Dissolve the salt in water in the flask. Stir to make sure all the salt is dissolved.**
2. **Set up the apparatus as shown in the diagram:**


Delivery Tube
Rubber stopper
Plastic tube
Test tube
Flask
Ring
Beaker with ice cubes
Alcohol burner

3. **After the teacher has checked your setup, start the distillation.**
4. **Heat the solution in the flask gently for 5 - 10 minutes.**
5. **Cap the alcohol burner and remove the test tube from the beaker.**
6. **Taste the water in the test tube by placing a drop of water on the tip of your finger and touching your finger to the tip of your tongue.**

7. Does the water taste salty?____________________.

8. Where is the salt?____________________. Why?____________________.

9. What process was used to separate the water from the salt?____________________.

10. In what state (liquid, solid, or gas) was the water that came out of the flask?____________________.

11. In what state is the water in the test tube?____________________.

12. Why was the ice necessary?____________________.

13. What is the name of this process?____________________.

14. How does the liquid in your test tube compare with the liquid in the teacher's beaker?____________________.

Conclusions

1. Sea water may be made fit for drinking by first____________________the water and then____________________.

2. The combination of these two steps is called____________________.

3. The Liebig condenser is a special piece of apparatus used for____________________.

SUSPENSIONS AND EMULSIONS

Suggested Lessons and Procedures

15. WHY ARE SOME LIQUIDS CLOUDY?

Outcomes

- Some solids mix with water but do not dissolve to form solutions.
- Particles of such mixtures, which are called suspensions, are much larger than particles of solutions.
- Particles of suspensions are visible, vary in size, and usually settle if undisturbed.
- The weight of the particles determines how fast they settle.
- Particles in suspension can be filtered.
- The pores of a filter must be smaller than the size of the particles.
- *The solid is called the dispersed substance and the liquid is called the dispersing medium.*
- *Suspension may be in all combinations of states of matter except gas in gas.*

Motivation

Have the pupils recall the first lesson in which they learned that solutions are clear, the particles are too small to be seen and do not settle. Display a mixture of powdered chalk and water. Ask, "Is this a solution?" "Why not?"

Development

1. Display and identify the following four mixtures in test tubes:
   a. fine sand and water
   b. powdered chalk and water
   c. powdered clay and water
   d. solution of copper sulfate

2. Have the pupils distinguish between the clarity of the solution and the suspensions. Define *suspension.*

3. Turn off the lights and shine a flashlight through each of the test tubes. Elicit that we see the path of light in the suspensions because the particles are large enough to reflect light.

3a. Identify this effect as the Tyndall effect.

4. Pass stoppered test tubes of suspension among the pupils and have them note the comparative sizes of the particles. Help them to generalize that particles of suspensions vary in size.

5. Have a pupil shake the three test tubes with suspensions, and note that the particles settle at different rates for the different suspensions. Ask, "What connection is there between the size of the particle and the time it takes to settle?" Elicit that if the particles are heavier, they settle faster.

6. Question pupils about other forms of suspensions involving other states of matter. Example:
   — Air in a bar of floating soap may be considered a gas suspended in a solid.
   — Elicit that steam is a suspension of water droplets in a gas (air).

6a. Ask, "Is a gas always of molecular size?" "Do gases form a homogeneous mixture?" Establish that a gas mixed with a gas is a solution (ex., air). Help pupils to generalize that suspensions may occur in all combinations of states of matter except a gas in a gas.

7. Ask, "How does your mother get spaghetti out of the cooking water? Elicit that solids can be removed from a liquid by filtration. Filter the suspension of powdered clay through a piece of wire gauze over a beaker. Ask, "Why do the particles go through?" Elicit that the openings are too large.

Filter the suspension, using filter paper. Ask, "What is happening now?" "Why do the particles remain in the filter paper?" Elicit that the pore openings are smaller than the particles.

Have pupils recall that solutes cannot be filtered out of a solution. Elicit that solutes are smaller than the pores of any filter.

Help pupils to generalize that in order to filter out a substance from a suspension, the pores of the filter must be smaller than the substance.

8. Guide a discussion on how rivers erode soil and carry it out to sea as suspensions. Ask, "Does the soil remain in the sea as a suspension?" Elicit that the suspended soil settles and forms deltas such as the deltas of the Mississippi and Nile Rivers. This settling is called ***sedimentation.***

Summary

1. Have the pupils make and complete this chart:

	SOLUTIONS	SUSPENSIONS
Mixture is (clear, cloudy)		
Light passes through (yes, no)		
Particles settle (yes, no)		
Particles are large (yes, no)		
Mixture is homogeneous (yes, no)		
Particles dissolve (yes, no)		
Particles are visible (yes, no)		
Particles are filterable (yes, no)		

2. *In a suspension the __________ substance is in the __________ medium.*

3. *A gas in a gas is always a __________.*

Homework

1. Stir a teaspoonful of starch in a glass of water. Answer the questions on the chart for your mixture of starch and water.

2. Why do some medicines have a label which reads, "Shake well before using?"
3. *When a beam of light shines into a room we see dust particles in the light beam. Is this a suspension? Why?*

Materials

Fine sand
Powdered chalk
Powdered clay
Three 8" test tubes
Stoppers to fit test tubes
Copper sulfate solution
Flashlight
Stand
Ring clamp
Funnel
Filter paper
Stirrer

16. HOW CAN WE GET THE PARTICLES OUT OF AN ORDINARY SUSPENSION?

LABORATORY LESSON

Outcomes

- Suspended particles may be identified by visual inspection, using a beam of light.
- Particles in a suspension may be separated by sedimentation, filtration, and coagulation.

Motivation

Display a 500 ml beaker containing 300 ml of an unknown mixture (see "Materials" at end of lesson) and ask, "How can we find out what kind of a mixture we have?"

List the answers on the board. Challenge pupils to devise ways of separating the different parts of the mixture.

Development

1. Distribute materials to each group.
2. Have each group of pupils plan their procedures and tests for two samples. Move about the room and help the groups with special

problems. Guide them to use sedimentation with one portion of the mixture and filtration with the other portion.

3. When all groups have planned their work to include filtration, demonstrate the correct method of preparing the filter and filtering.
4. Distribute to each group a stoppered, 8″ test tube filled with the mixture of topsoil, potassium permanganate, and cornstarch.
5. After the pupils have finished testing the two samples, tell them to follow the instructions on the Worksheet for testing sample #3.
6. Define the new terms introduced in this lesson.

Homework

1. Why do quiet ponds have clear water?
2. Why is spring water, which comes up through the soil, so clear?
3. When preparing cooked cereal, why must we keep stirring it?
4. Name three liquid mixtures (used in the home) which are suspensions.

Materials

500 ml beaker
300 ml of a mixture containing topsoil, potassium permanganate, and cornstarch in water.

NOTE: Add concentrated ammonium hydroxide to the saturated alum solution which is listed in "Materials" on the Worksheet.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 16

Problem: How can we separate the different parts of a mixture?

Materials

Test tube rack
Seven 8″ test tubes
Stand
Clamp (for test tube)
Ring clamp
Flashlight
30 ml of mixture
Stirrer
Iodine solution
Watch glass

Funnel
Filter paper
Alcohol burner
Medicine dropper
5 ml saturated alum solution
Test tube holder

Procedure and Observations

1. With the other members of your group, plan a way to separate the parts of the mixture and determine whether the liquid part is a solution or a suspension.

2. Let your teacher check your plan *before* you proceed.

3. Divide your mixture equally into three test tubes. Follow the steps in your procedure, using test tubes #1 and #2. Set test tube #3 aside.

   Answer the following questions as you do your work:

   a. With what kind of mixture are you starting?________________.
      1. How do you know?________________.
      2. Which separation method are you using first?________________.
      3. What do you see? (observation)________________.
      4. What type of mixture do you have left?________________.
      5. How can you tell?________________.

   b. Which separation method are you using now?________________.
      1. What do you observe?________________.
      2. What type of mixture do you have left?________________.
      3. How can you tell?________________.

4. Heat the mixture in test tube #3 until it starts to boil. Be careful to point the test tube away from yourself and your neighbors. Filter the mixture in test tube #3. Use the medicine dropper to transfer some of the filtrate (the liquid which passed through the filter paper) to the watch glass.

5. Add a few drops of iodine solution to the filtrate on the watch glass.

   a. Iodine is a test for the nutrient,________________.
   b. If this nutrient is present, the color will change to________________.
   c. Do you have a positive test?________________.
   d. The filtrate contains________________.

6. Add 5 ml of saturated alum solution to the filtrate. Stir the mixture and let it stand for a few minutes. Stir the mixture again and filter it.

7. Test the new filtrate for the presence of starch.

   a. Starch________________(is, is not) present in this filtrate.
   b. The alum caused the particles to become________________(larger, smaller).
   c. *Coagulation* causes small particles to clump together so that they ________________(can, cannot) pass through filter paper.

Conclusions

1. If a mixture of a solid and a liquid is cloudy the mixture is a__________.
2. Three ways of separating the solid from such a mixture are__________ __________ and __________.
3. The flashlight was needed because a beam of light is__________ in a suspension.
4. If a mixture of a solid and a liquid can be filtered the mixture is a __________.
5. In suspensions the solid portion often__________to the bottom.
6. Alum was used to__________.

17. WHAT ARE SOME SPECIAL KINDS OF SUSPENSIONS?

Outcomes

- An emulsion is a special kind of suspension of two immiscible liquids.
- A substance that keeps an emulsion from separating is called an *emulsifying agent.*
- *Colloids* are a special kind of suspension.
- Colloidal particles do not settle out.
- *Colloidal particles reflect light* (Tyndall effect).
- *Colloidal particles cannot be filtered out with ordinary filter paper.*
- *The particles in a colloid are made of many molecules.*

Motivation

Display a mixture of 5 ml of oil and 15 ml of water in a test tube. Ask, "Does the oil mix with the water?" Review the term *miscible* (mixable). Identify oil and water as *immiscible.* Ask, "How can we make the oil mix with the water?"

Development

1. Add 5 ml of liquid soap to the test tube containing oil and water.

Shake the test tube vigorously. Display the test tube and have the pupils observe that the oil and water have mixed. Explain that the mixture is called an *emulsion.*

4. Place the test tube in the rack for a few minutes. Pose the question, "Does the oil separate from the water?" Establish that although the liquids are not soluble in each other ordinarily, in an emulsion they do not separate easily. Identify an emulsion as a special kind of suspension.
5. Ask, "Why did we add the soap?" Identify the soap as the substance which did not permit the oil molecules to come together and float to the top. A substance which acts like the soap is called an *emulsifying agent.*
6. Demonstrate how mayonnaise is made by performing the following: In a large test tube, pour 10 ml of vinegar and add 40 ml salad oil, stopper the tube and shake it vigorously. Show the pupils that the liquids are *not miscible.* Add the yolk of an egg and repeat the shaking. Have the pupils conclude that the liquids do not separate now. "What is this suspension called?" "What is the emulsifying agent?"
7. To demonstrate a colloid, mix some Congo red with water in one test tube; and sand and water in another test tube as a control. Stir each mixture. Review the properties of a suspension. Allow the test tubes to stand for a few minutes. Elicit what happened to the sand and the dye. Lead the pupils to conclude that while both mixtures were suspensions, the sand settled although the Congo red did not. Identify the Congo red mixture as a *colloid.*
8. Elicit the definition of a colloid as a special kind of suspension whose particles do not settle.
9. Mention some examples of common colloids such as glue, gelatin, and protoplasm.
10. *Shine a light through the test tubes of sand and water, and Congo red and water. (Stir the sand again.) Ask the pupils to describe what they see. Identify this as the* Tyndall effect.
11. *Set up 2 funnels, each with filter paper. Filter each mixture into a beaker. Ask, "Which mixture went through the filter paper?" Establish that particles in a colloid will pass through ordinary filter paper. Refer back to the properties of solutions. Recall that*

the particles in a solution are molecular in size. Explain that particles in a colloid are made up of many molecules, but are still small enough to pass through filter paper. Explain that it is possible to have a filter with tiny pores which would not permit the particles of a colloid to pass through.

Summary

Complete the following chart at the chalkboard.

	SOLUTION	SUSPENSION	EMULSION	COLLOID
1. Cloudy or clear? 2. Is the mixture transparent? 3. Do the particles settle out? 4. Is the mixture homogeneous?				
5. Are the particles molecular in size? *6. Do the particles reflect light?*				

Homework

1. Why do you shake a bottle of salad dressing before using it? Why don't you shake mayonnaise?
2. Explain why we use detergents to wash greasy dishes.
3. *For extra credit:*
   Mix some gelatin with hot water and stir. Allow the mixture to cool at room temperature (not in the refrigerator). Place a paper towel over the top of a glass and carefully pour the mixture onto the towel. Does the gelatine mixture pass through the paper towel? What kind of mixture is this? Place the gelatin mixture into the refrigerator and allow it to set. Is this a solution, suspension, emulsion or a colloid? Explain.

Materials

5 ml oil
15 ml water
40 ml salad oil
Yolk of an egg

5 ml liquid soap
4 test tubes
Test tube rack
10 ml vinegar

Light source
2 funnels

Congo red
Sand
Stirring rod
Stopper

Filter paper
2 beakers

18. WHAT SPECIAL METHODS CAN BE USED TO REMOVE PARTICLES FROM A SUSPENSION?

Outcomes

- Coagulation may be used to speed up the rate of sedimentation. Coagulation causes small particles to clump together and make them filterable.
- The centrifuge is a more rapid means of separating suspended particles. The centrifugal (outward) force presses the particles against the bottom of the centrifuge tube.
- *Colloidal particles may be separated by centrifugation.*
- *Adsorption may be used to separate colloidal particles.*

Motivation

Make a suspension of topsoil in water. Ask, "How can we separate the soil?" After eliciting sedimentation and filtration from the pupils, ask, "Would making the size of the particles larger change the speed at which they settle out?" "How can we make the particles larger?"

Development

1. Make a duplicate suspension of topsoil in water.
2. To the second test tube, add 15 ml of saturated alum solution and 5 ml of concentrated ammonium hydroxide.
3. Ask the pupils to describe what happens to the mixture in test tube #2. Lead them to understand that the alum forms a jelly-like material to which the suspended particles can stick. In this

manner, the particles become larger and heavier and settle to the bottom.

4. This method of using chemicals for separating suspended particles is called *coagulation*.

5. Have the pupils conclude that coagulation speeds up the rate of sedimentation by increasing the size of the particles.

6. Centrifuge a sample of the topsoil and water mixture used in the first demonstration. A home-made *centrifuge* may be made by tying a short length of strong cord under the lip of a test tube and whirling the test tube.

CAUTION: Test this before class and make sure the tube is secure and will not fly out.

Ask the pupils to describe the material in the centrifuge tube (or test tube).

7. Guide the pupils to understand that the outward force presses the soil against the bottom of the tube, thus separating the suspended particles from the liquid. Have the pupils relate this centrifugal (outward) force to the action of certain rides in amusement parks and to the action of a washing machine.

8. *Make a colloidal suspension of finely powdered clay in water. Lead the pupils to establish that this is a colloid. Centrifuge the mixture and elicit the fact that colloidal particles may be separated by centrifugation.*

9. *Define* adsorption. *Add some diatomaceous earth to a sample of the clay and water mixture and allow it to settle. Ask the pupils to describe the results. Elicit the conclusion that adsorption may be used to separate colloidal particles.*

Summary

1. What does alum do to the particles in a suspension?

2. The method of using chemicals for separating suspended particles is called____________.

3. Sedimentation may be speeded up by____________(increasing, decreasing) the size of the particles.

4. Coagulation causes small particles to clump together so they __________ (can, cannot) pass through filter paper.

5. Whirling a test tube at high speed is called __________.

6. What does the outward force do to the soil in the mixture?

7. How does the spinning cycle in the washing machine wring out the clothes?

8. *What effect did the centrifuge have on the particles of a colloid?*

9. *How did the diatomaccous earth remove the clay from the water?*

Homework

1. What could be added to the water in a swimming pool to remove suspended particles? How would it work?

2. Tie a string around the neck of a plastic bottle. Place a mixture of soil and pebbles in the bottle. Cover the bottle and whirl it around to centrifuge the mixture. Describe the results.

3. *Place 1" of sand into a glass, add 2 teaspoonfuls of oil, and stir. In another glass, make a solution of 2 teaspoonfuls of sodium carbonate (washing soda) or sodium bicarbonate (baking soda) in ¼ glassful of water. Add this solution to the sand and oil mixture, and stir. Allow the glass to stand for 10 minutes. Examine the contents of the glass. Describe what you see. Explain what happened.*

Materials

Five 8" test tubes and rack
100 ml suspension of topsoil in water
20 ml saturated alum solution
6 ml conc. NH_4OH

Colloidal suspension of finely powdered clay
Diatomaceous earth
2 test tubes

Funnel
Filter paper
Stirring rod
Centrifuge (or test tube and string)

19. WHAT ARE SOME METHODS FOR MAKING EMULSIONS AND COLLOIDS MORE STABLE?

Outcomes

- Mechanical devices, such as blenders, may be used to make the particles of an emulsion so small that they will remain suspended.
- Chemical emulsifiers can make emulsions more permanent by causing them to gel.
- *The coagulation of suspended particles may be prevented by adding a second colloid, known as a protective agent.*

Motivation

Set up a glass container of homogenized milk and one of non-homogenized milk (allowed to stand so the fat rises to the top). Ask pupils to describe both samples of milk. Ask, "What is the difference between the two types of milk? How can we change the approved milk to homogenized milk?"

Development

1. Make a slide of the homogenized milk and place it on the stage of a bioscope. Shake the approved milk vigorously and repeat the same procedure. Ask, "How are the two types of milk different?"
2. Mix a sample of approved milk with an eggbeater, mixer, or blender. Prepare a slide and place it on the bioscope. Ask, "How does this compare with the homogenized milk?" "What did the vigorous mixing to do the fat in the milk?"
3. Ask, "How does mixing prevent the fat from settling out?" Explain that this method is called *homogenization*. In industry, however, milk is homogenized by forcing the fat globules through tiny pores, under high pressure.
4. Demonstrate some orange juice which has settled out. Ask, "How can we prevent the particles in the orange juice from settling out?" Following the pupils' suggestions, shake a sample of juice and set it aside. Show the pupils that the particles settle out readily.

5. To a sample of orange juice, add some commercial pectin. (ex. Sur-gel) Bring the mixture to a boil and allow it to cool. Permit the pupils to examine the cooled mixture and ask, "What did the pectin do to the particles in the orange juice?" Guide the pupils to realize that this new substance is orange jelly. Help the pupils to conclude that chemical emulsifiers can prevent particles from separating by causing the formation of a semi-solid *gel.*

6. *Exhibit labels of some milk products (ex. ice cream and some cheeses) which have gelatin listed as one of the ingredients. Explain that gelatin will act as a protective colloid and prevent coagulation. In ice cream, gelatin adheres to the water molecules and prevents the formation of ice crystals.*

7. *Dissolve some sugar in alcohol. Lead the pupils to understand that the alcohol molecules adhere to the sugar molecules, thus preventing them from settling out.*

Summary

1. What effect does vigorous mixing have on suspended fat particles?
2. What is meant by homogenization?
3. How is milk homogenized?
4. How can we make jelly?
5. What does the addition of pectin do to the particles in fruit juice?
6. What is a gel?
7. *What is the action of a protective colloid?*
8. *What is solvation?*
9. *What is hydration?*

Homework

1. Gently boil a cup of apple juice until it gels. What does apple juice contain that makes this possible? How does this substance cause the gel to form?

2. What would you do to salad dressing to prevent the oil from separating? If possible, try it at home and bring a sample to class.

3. *Starch is sometimes added to water in a boiler to prevent the formation of deposits on the sides of the boiler. Explain how this could work.*

Materials

Stirring rod
Homogenized milk
Approved milk
Eggbeater, mixer, or blender
Microscope slides
Bioscope
Orange juice
Pectin (ex. Sur-gel)
Beakers (2)
Bunsen or alcohol burner
Ring stand, ring, wire gauze
Test tube holder

2 test tubes
Sugar
Alcohol

20. *HOW CAN WATER BE PURIFIED?

LABORATORY LESSON

Outcomes

- Rain and stream water are collected in reservoirs.
- Purification of water takes place in the following sequence:
  - Sedimentation
  - Coagulation
  - Filtration
  - Chlorination
  - Aeration

Motivation

1. Ask, "Where does our tap water come from? How is it purified so we can drink it safely?"

2. Exhibit a flask containing water to which soil and powdered clay have been added. Suggest that the water which flows into the reservoirs is similar to this.

---

* Only for classes programmed for five periods

Development

1. Elicit the procedures we might use to purify this water, and write them on the chalkboard.
2. Distribute the materials and proceed with the laboratory lesson.
3. **Note:** Prepare the saturated alum solution and add concentrated ammonium hydroxide before distributing to pupils. After the pupils have completed the steps for sedimentation, filtration, and coagulation, demonstrate chlorination:
    a. Place a Petri dish or a slide of a mixed culture of protozoans on the stage of a bioscope. Have the pupils observe the moving organisms.
    b. Set aside some of the culture as a control.
    c. Add a few drops of sodium hypochlorite (ex., Clorox) to the living organisms. Have the pupils observe the organisms again and find that they are now dead. Place the control sample back on the stage to show that these organisms are still alive.

    Ask, "What did the chlorine do to the living organisms? Why is drinking water chlorinated? Why do we add chlorine to water in pools?"
4. To demonstrate aeration, use a sample of boiled water and demonstrate aeration by pouring the water into another test tube several times. Ask, "What effect does this have on water?"

Summary

Have the pupils compare the original water sample with the purified samples. Elicit the procedures they used to arrive at the final sample.

Homework

1. Does well water have to be purified? Why?
2. Why isn't swimming permitted at some waterfronts?

Materials

Petri dish
Bioscope
Flask
Soil
Powdered clay
Clorox

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 20

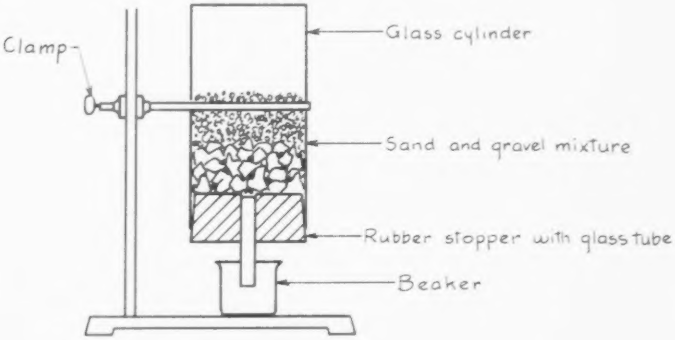
Problem: How is our drinking water purified?

Materials

Beaker containing 30 ml of water mixture
Beaker
2" dia. open-end glass cylinder or lamp chimney
One-hole rubber stopper with glass tube to fit cylinder or chimney
Ring stand
Clamp
10cc saturated alum solution
Test tube
Test tube rack
Sand and gravel mixture
Stirring rod

Procedure and Observations

1. Stir water mixture in the beaker. Pour ⅓ of the mixture into a test tube and set it in the rack. Go on to the next step and examine the first test tube in about 10 minutes.
2. Set the stopper (with the glass tube) into one end of the open cylinder. Pour the sand and gravel mixture into the cylinder and tap it gently several times. Which particles go to the bottom of the cylinder? ________________.
3. Arrange your equipment as shown in the diagram:



4. Stir the water mixture in the beaker and pour it into the top of the cylinder.

a. The water coming out into the beaker is ____________ (clear, cloudy).

b. Most of the particles are being removed from the water by the ____________.

c. This method of purifying water is called ____________.

5. Look at the test tube with the water mixture which you put in the rack.

a. What happened to some of the particles in the water? ____________.

b. This method of purifying water is called ____________.

6. Add 10 cc of saturated alum solution to the water which came out of the cylinder. Stir the mixture and let it stand for a few minutes.

a. What do you see on the bottom of the beaker? ____________.

b. The water near the top of the beaker is ____________ (clear, cloudy).

c. This method of taking fine particles out of water is called ____________.

Conclusions

1. Particles suspended in water will settle out by ____________.

2. Pouring water through sand and gravel is called ____________.

3. Fine particles are removed from the water by adding ____________. This method of purifying water is called ____________.

4. Harmful living organisms are destroyed by passing ____________ through the water. This method of purifying water is called ____________.

5. Aerating water improves the ____________ of the water.

ACIDS, BASES, AND NEUTRALIZATION

Suggested Lessons and Procedures

21. HOW CAN WE RECOGNIZE ACIDS?

Outcomes

- Acids are a special group of chemical substances.
- Many common substances are, or contain, acids.
- Acids can be recognized by such properties as:
  - a. sour taste
  - b. changing colors of certain substances
  - c. reacting with metals such as zinc or magnesium.
- All acids contain hydrogen.
- *Indicators are a class of substances which change color in acids.*
- *Acids show their properties in solution.*

Motivation

Display and identify the following solutions in test tubes:

a. boric acid
b. acetic acid
c. citric acid
d. hydrochloric acid

Ask pupils to tell where these substances are found and/or what use they serve. Add four test tubes, each containing water, to the rack. Rearrange the order of the 8 test tubes and ask, "Which of these test tubes contains acid?"

Development

1. Show the pupils a glass of sour milk, a lemon, and vinegar. Ask, "What is similar about their taste?" Elicit that they are all sour. Tell them that sour milk contains lactic acid, lemon contains citric acid and vinegar is acetic acid. Have pupils generalize that acids are sour.

   Caution pupils that although the sour taste is a property of acids, chemists do not use this test because many acids are poisonous.

1a. Tell pupils that the word acid comes from the latin word acidus which means sour.

2. Ask, "How can we recognize an acid without tasting?" Help pupils to understand that since we cannot see acids in substances we can test for them by the way they affect other substances.

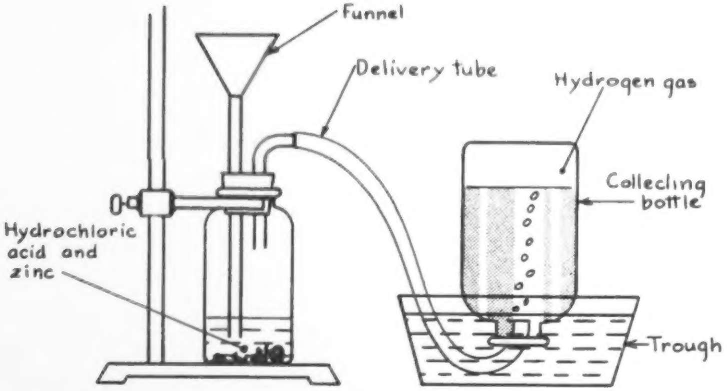
3. Display and identify a solution of litmus which has been made basic. Pour 5 ml of litmus solution into a test tube and add 5 ml of acetic acid. Ask, "What effect does the acid have on litmus?" Repeat the demonstration with distilled water as a control. Elicit that we can recognize acids by using a substance which changes color when an acid is added.

3a. Display and identify a solution of basic phenolphthalein. Repeat the demonstration using phenolphthalein and hydrochloric acid. Help pupils to understand that there are many substances which change color when they become acidic. Introduce and define the term indicator.

4. Show and identify a strip of blue litmus paper. Have a pupil use a glass stirring rod to place a drop of liquid, from the test tubes used for the demonstration, on a strip of litmus paper to identify the test tubes which contain acid. The stirring rod should be rinsed after each use. Ask, "Why is litmus paper used instead of litmus solution?" Distribute to each pupil a three-inch strip of litmus paper to be used for homework.

4a. Test citric acid powder for acidity with dry litmus paper. Dissolve 5 grams of the powder in water and retest. Elicit that acids show their properties when they are in solution.

5. Set up a hydrogen generator as shown: For specific safety precautions to be taken, refer to the manual, *For Greater Safety in Science Teaching*, Board of Education, 1964 edition.



Collect the gas and test for hydrogen. Ask, "Was there a chemical reaction?" "How could you tell?" "From where did the hydrogen come?" Elicit that a chemical reaction occurred between the zinc and the acid, that hydrogen was given off, and that the zinc replaced the hydrogen.

6. Write the formulas of several acids on the chalkboard: $H_3C_6H_5O_7$ (citric acid), H_3BO_3 (boric acid), $HC_2H_3O_2$ (acetic acid), HCl (hydrochloric acid), H_2SO_4 (sulphuric acid). Ask, "Which element do all the acids contain?" Help pupils to generalize that hydrogen is the only element common to all acids. Care should be taken to help pupils understand that hydrogen in a substance does not necessarily make it an acid but all acids have hydrogen.
7. Discuss with pupils the uses of common acids in the manufacture of many products.

Summary

1. Name three common acids which are found in the home.
2. What kind of taste do acids have?
3. Why don't chemists use the taste test?
4. What substance can be used to test for acids?
5. What happens to this substance when it becomes acidic?
6. What is released when zinc is added to an acid?

7. **Which element is present in all acids?**

8. ***What is an indicator?***

9. ***In what condition must an acid be to show its properties?***

Homework

1. **Use your litmus paper to test substances at home. Use only one drop just as you saw it done in class. Here are some suggestions: Apples, tomato juice, water, ammonia water, milk, soda. Make a table showing whether each substance which you tested is an acid or not.**

2. How do you know that acids contain hydrogen?

3. ***When an acid is dissolved in water, something happens to the molecules. What evidence can you offer to support this statement?***

Materials

4 test tubes each containing one of the following acids: boric, acetic, citric and 0.1N HCl
Test tubes and rack
Glass of sour milk
Lemon
Vinegar
Litmus solution
Distilled water
Stirring rod
Wood splint
Hydrochloric acid (0.1N)
Ring stand
Clamp
Bottle fitted with 2-hole stopper holding funnel and tubing with right angle bend
Rubber delivery tube
Zinc
Litmus paper (for use by pupils)

22. WHAT IS A BASE?

Outcomes

- Many common substances are bases or contain bases.
- Bases can be recognized by such properties as:
  - slippery feel
  - bitter taste
  - changing red litmus to blue

- **Bases have a hydroxyl group (OH).**
- ***Acids are nonmetals combined with hydrogen. Bases are metals in combination with hydroxide groups.***

Motivation

Place a few drops of dilute hydrochloric acid on fresh blue litmus paper. Pupils will note that these areas turn pink.

Ask pupils to suggest what would happen if ammonia water were placed on these pink spots.

Demonstrate and have pupils conclude that this is the opposite action of an acid. Identify this property as characteristic of a base.

Identify ammonium hydroxide (ammonia water) as a base.

Development

1. Display a can of lye, a bottle of household ammonia, and a bottle of milk of magnesia. Have pupils explain the uses of these materials, (e.g., lye — to clean drains; ammonia — to clean windows; milk of magnesia as a laxative).
2. Have a pupil rub a few drops of a very dilute solution of sodium hydroxide (0.1N) between his fingers and elicit that the substance has a slippery or soapy feel. The pupil must rinse his hands thoroughly after touching the base.
3. Ask pupils whether they have ever tasted milk of magnesia. Have a pupil taste a little and elicit that the base has a bitter taste. Repeat the warning about tasting to test something. Explain that milk of magnesia was tasted because it is a known laxative.
4. Identify lye as sodium hydroxide, milk of magnesia as magnesium hydroxide, and ammonia water as ammonium hydroxide. Display and identify dilute solutions of each base. Have a pupil test the solutions with red litmus paper. Elicit that bases turn red litmus paper blue. Relate to the property that acids turn blue litmus red.

4a. Demonstrate with phenolphthalein in addition to litmus. Guide pupils to understand that a change from colorless to red is a change of color.

5. Recall the reaction of acids with zinc. Place a piece of mossy zinc

in a solution of sodium hydroxide. Have pupils observe that no reaction occurs. Help pupils generalize that acids enter into reactions different from bases.

6. Place this chart on the chalkboard:

COMMON NAME	FORMULA	CHEMICAL NAME
lye	$NaOH$	sodium hydroxide
milk of magnesia	$Mg(OH)_2$	magnesium hydroxide
ammonia water	NH_4OH	ammonium hydroxide
slaked lime	$Ca(OH)_2$	calcium hydroxide

Ask, "Which elements do all bases have in common?" Elicit that the elements are oxygen and hydrogen. Help the pupils to understand that when these two are united, the new name is *hydroxide.*

6a. Introduce the term radical when discussing the hydroxide radical. Indicate that it is a group of two or more atoms which act as a unit.

7. Have pupils recall the previous lesson and generalize that acids have hydrogen (H) and bases have hydroxide (OH) in their molecules.

8. Help pupils to reason that if acids have similar properties and have only hydrogen in common, then the acid property must be due to the hydrogen. The same kind of reasoning will lead to the conclusion that the properties of bases must be due to the hydroxide part.

8a. Guide pupils to understand that acids are nonmetals combined with hydrogen and bases are metals combined with the radical hydroxide.

Summary

1. Some bases which may be found in the home are __________ and __________.
2. Bases feel __________ and taste __________.
3. Bases change the color of litmus from __________ to __________.

4. **Bases (do, do not)__________react with metals.**

5. **Bases have the element(s)__________.**Acids have the element __________in their molecules.

6. An (OH) pair in a molecule is called__________.

7. The properties of acids are due to the__________part of the molecule.

8. The properties of bases are due to the__________part of the molecule.

9. *Phenolphthalein is__________in acid solution and__________ in basic solutions.*

10. *The radical common to many bases is__________.*

11. *An acid is__________combined with a nonmetal.*

12. *A base is a__________combined with a__________.*

Homework

1. Make your own testing solution. If available, boil red cabbage leaves or red radish skins in water. Continue heating until the water has evaporated almost to dryness and then add a small amount of alcohol. With this solution, test some things at home.
2. Name 4 ways in which acids and bases are different.
3. *What effect do acids and bases have on substances such as tea and grape juice? Can you use these as indicators? Why?*
4. *Can you find other substances which would serve as indicators?*

Materials

0.1N hydrochloric acid
0.1N ammonium hydroxide
0.1N sodium hydroxide
Litmus paper
Can of lye
Bottle of household ammonia
Milk of magnesia
Mossy zinc
Stirring rod

Phenolphthalein solution

23. WHAT HAPPENS WHEN AN ACID IS MIXED WITH A BASE?

LABORATORY LESSON

Outcomes

- Acids and bases neutralize each other.
- In neutralization, an acid combines with a base to form a salt and water.
- Neutral solutions do not change the color of litmus paper.
- Neutralization can be used to determine the relative concentrations of an acid and a base.
- *Salts of strong acids and strong bases are neutral.*
- *Salts of weak acids and weak bases are neutral.*
- *Salts of strong acids and weak bases are acidic.*
- *Salts of strong bases and weak acids are basic.*

Motivation

Display a bottle of household ammonia. Ask a pupil to find the antidote on the label. Ask, "Is ammonia an acid or a base?" "Are lemon juice and vinegar acids or bases?" "Why is this antidote suggested?"

Development

1. Make up 0.1M solution of sulfuric acid as follows:
   Slowly, stirring, add 167 ml of 18M acid (stock solution of concentrated H_2SO_4) to 500 ml water, then dilute to one liter. This will yield 3M H_2SO_4. Dilute 33 ml of 3M H_2SO_4 to 1 liter to yield 0.1 M H_2SO_4.
2. Make up 0.1M solution of barium hydroxide as follows:
   Dissolve 35 grams of $Ba(OH)_2$ by heating with 1 liter of water in an Erlenmeyer flask.

   NOTE: Calcium hydroxide may be used in place of barium hydroxide.
3. Caution the pupils in the handling of these solutions in the lab experience, and remind them to rinse glassware and stirrers thoroughly before re-using.

4. Distribute materials and proceed to laboratory lesson.

5. When the pupils have completed Procedure #4d (on the Worksheet), stop work and develop the chemical equation for the reaction on the chalkboard.

5a. Test the water and prove it is neutral. Explain that barium hydroxide is a strong base and sulfuric acid is a strong acid and they yield a neutral salt.

5b. A weak acid and a weak base will also yield a neutral salt. For example, ammonium acetate or aluminum sulfide. Dissolve the salt in water and test for neutrality.

5c. To demonstrate an acid salt, formed by a strong acid and weak base, dissolve aluminum chloride in water and test with blue litmus.

5d. To demonstrate a basic salt, formed by a strong base and a weak acid, dissolve some sodium carbonate in water and test with red litmus.

6. Explain that this process is called ***neutralization.***

7. Instruct the pupils to continue with the procedures on the Worksheet.

   a. It took__________drops of barium hydroxide to neutralize 10 drops of sulfuric acid.

   b. The solution is neutral when the litmus paper__________ (changes color, does not change color).

   c. Which is more concentrated (stronger), the barium hydroxide or the sulfuric acid?__________

   d. The white solid in the test tube is a__________.

8. Place 1 inch of water into each of two test tubes. Add a strip of red litmus paper to one test tube and blue litmus paper to the other test tube.

   a. The red litmus paper__________(did, did not) change color.

   b. The blue litmus paper__________(did, did not) change color.

   c. Water is__________(acid, base, neutral).

Conclusions

1. Barium hydroxide is a__________(acid, base.)
2. Sulfuric acid is an__________(acid, base.)
3. When an acid combines with a base, we call it__________.
4. An acid plus a base forms__________ and __________.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 23

Problem: How can barium hydroxide be neutralized by sulfuric acid?

Materials

Dropper bottle of 0.1M barium hydroxide
Dropper bottle of 0.1M sulfuric acid
Red and blue litmus papers
Glass stirring rod
Test tube rack
4 small-size test tubes

Procedures and Observations

1. Place a few drops of barium hydroxide on a piece of red litmus paper.
   a. the color of the litmus paper is__________.
   b. this shows that barium hydroxide is__________(an acid, a base).
2. Use litmus paper to test sulfuric acid.
   a. Use__________(red, blue) litmus paper.
   b. The color changed from __________ to __________.
3. Place 20 drops of barium hydroxide into a test tube. Add a strip of blue litmus paper to the test tube.
4. Add sulfuric acid to the test tube, one drop at a time, stirring after each drop has been added. Count the number of drops of acid you add until the litmus paper just changes color.
   a. We mixed a base with an__________.
   b. We added __________drops of sulfuric acid.
   c. A __________formed in the test tube.
   d. The liquid in the test tube is __________(clear, cloudy) and __________(colored, colorless).
   e. When an acid is added to a base, we get a __________ and __________.

f. $Ba(OH_2) + H_2SO_4 \rightarrow$ ______________________ + ______________________.

5. In another test tube, place 10 drops of sulfuric acid and a piece of red litmus paper. Count the number of drops of barium hydroxide it takes to neutralize the acid. (Add the base until the litmus just changes color and subtract the last drop from the total number of drops.)

Summary

1. Define neutralization.
2. Do neutral solutions change the color of litmus paper?
3. If we mix sodium hydroxide ($NaOH$) and hydrochloric acid (HCl) what salt would we get? $NaOH + HCl$.

Homework

1. Which would you add to vinegar (acetic acid) to make it neutral, lemon juice (citric acid) or ammonia (ammonium hydroxide)? Explain the reasons for your choice.
2. If it takes 5 drops of acid to neutralize 10 drops of a base, which is more concentrated (stronger?) Why?
3. What is meant by neutralization?

Materials

Ammonium acetate or
Ammonium solfide
Aluminum chloride
Sodium carbonate

4 beakers
Red and blue litmus
Stirring rod

24. HOW DO ACIDS AND BASES CHANGE THE ELECTRICAL PROPERTIES OF WATER?

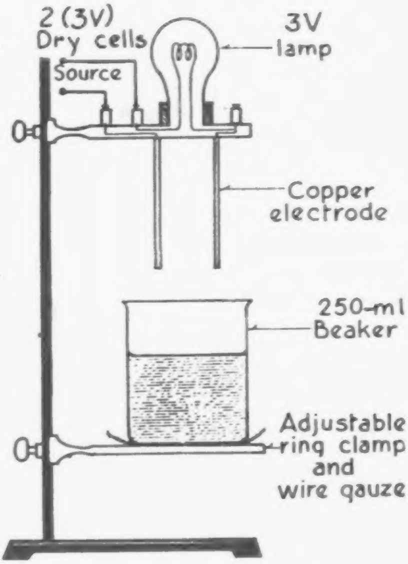
Outcomes

- Pure water does not conduct electricity.
- Solutions of acids and bases will conduct electricity.
- Solutions which conduct electricity are called electrolytes.

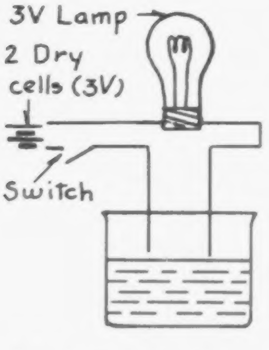
- **Dilute solutions of acids and bases conduct electricity better than concentrated solutions.**
- ***An electron is a negatively charged particle which orbits around the nucleus of an atom.***
- ***Electricity is the flow of electrons.***

Motivation

1. Set up the apparatus as shown: (or Cenco #81180).


2 (3V)
Dry cells
Source
3V
lamp
Copper
electrode
250-ml
Beaker
Adjustable
ring clamp
and
wire gauze

2. Draw the circuit diagram on the chalkboard as shown:


3V Lamp
2 Dry
cells (3V)
Switch

3. Ask, "Why doesn't the light go on?" Elicit that this is a series circuit with an open space between the electrodes.
4. Ask, "How could we make the electricity flow in this circuit?" Try out some of the suggestions made by the pupils, such as making the electrodes touch, connecting a wire between the electrodes, or placing a metal bar across the electrodes. Lead the pupils to conclude that closing the circuit will cause electricity to flow and the light will go on.

5. Before placing the electrodes into a 250 ml beaker of distilled water, ask whether they think water will conduct an electric current. Demonstrate that the light does not go on.

6. Ask, "How can we make electricity flow through the water?"

Development

1. Add 10 ml of acetic acid to the distilled water. Have the pupils conclude that the addition of the acetic acid caused the light to go on.

2. Ask the pupils to suggest some other acids such as hydrochloric acid and sulfuric acid. Lead them to conclude that most acid solutions will conduct electricity.

3. Ask, "How can we find out if bases will cause water to conduct electricity?" Using the same techniques as in Step 1 and Step 2, demonstrate the electrical conductivity of a solution of ammonium hydroxide. Ask, "What substances will cause electricity to flow through water?"

4. Explain that solutions which conduct electricity are called *electrolytes*. Ask, "Is distilled water an electrolyte?"

5. Place some dry, solid sodium hydroxide into a dry beaker and test it for electrical conductivity. Ask, "Why doesn't the light go on?" "What shall we add to the sodium hydroxide to make it conduct electricity?" Add 50 ml of water to the beaker and guide the pupils to observe the brightness of the lamp. Have pupils conclude that dry solids are non-conductors of electricity.

6. Review the definitions of dilute and concentrated solutions. Ask, "Is this solution dilute or concentrated?" "How can we make the solution more dilute?" Continue to add water to the solution. Ask, "What is happening to the light?" "Which is a better conductor of electricity, a concentrated solution of sodium hydroxide or a dilute solution?"

7. Into a clean dry beaker pour enough glacial acetic acid to cover the ends of the electrodes. Demonstrate its electrical conductivity. Ask, "How can we make the light brighter?"

8. Add water to the acetic acid and lead the pupils to observe the brightness of the lamp. Ask, "Which is a better conductor of

electricity, a concentrated solution or a dilute solution of an acid?" Lead the pupils to conclude that dilute solutions of acids and bases are better electrolytes than concentrated solutions.

9. *Review the basic structure of an atom (7th grade Chemistry). Elicit the definition of an electron. Guide pupil volunteers in the drawing of an atom of hydrogen and an atom of chlorine on the chalkboard.*

   Review the formation of the compound HCl.

10. *Ask, "What is an electric current?" Review the definition of an electric current as the flow of these electrons.*

Summary

1. What is an electrolyte?
2. Does pure water conduct electricity?
3. Name 3 acids which conduct electricity.
4. Name 3 bases which conduct electricity.
5. Which will conduct electricity better, dilute solutions of acids and bases or concentrated solutions?
6. Does dry sodium hydroxide conduct electricity? Why?
7. *What is an electron?*
8. *Where is the electron located in an atom?*
9. *How do atoms combine to form compounds?*
10. *What is electricity?*

Homework

1. Connect 2 wires to a flashlight bulb. Tape the other end of each wire to a penny. Cut a lemon in half and stick the pennies into the lemon, making sure that the pennies do not touch each other. Does the light go on? Explain what happens.
2. If you dissolve sugar in water, will it conduct electricity? Explain your answer.
3. Name 3 things you have around the house which will make good electrolytes.

Materials

3 volt lamp
Lamp socket
Switch
2 dry cells
Wires
2 copper electrodes
Metal bar
Wire with 2 alligator clips
Glass stirring rod
250 ml beakers
600 ml distilled water
10 ml acetic acid
10 ml dil. HCL.
10 ml dil. H_2SO_4
10 ml dil. NaOH
10 ml dil. $Ba(OH)_2$
10 ml dil. NH_4OH
10 ml glacial acetic acid
Conductivity apparatus

Chart of atomic structure or atomic model

25. *WHAT COMMON ACIDS AND BASES ARE FOUND IN THE HOME?

LABORATORY LESSON

Outcomes

- Many acids and bases are used in the home.
- Some solutions used in the home are neither acid nor base.

Motivation

1. On the day previous to this lesson, the pupils should be assigned to bring some samples of household solutions to class for testing in the laboratory. The teacher may suggest such items as:

   Orange juice
   Tomato juice
   Apple juice
   Household ammonia
   Baking soda
   Washing soda
   Skim milk
   Vinegar
   Lemon juice
   Grapefruit juice
   Pineapple juice
   Milk of magnesia
   Alcohol
   Oil

2. Instruct the pupils to place the items on the desk and ask, "Can you tell if these substances are acids or bases? How can we find out?"

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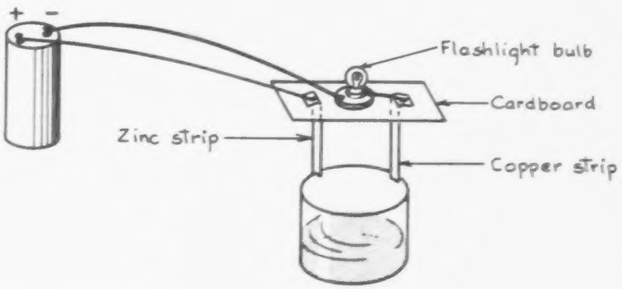
* Only for classes programmed for five periods

Development

1. Distribute the materials and proceed with the laboratory lesson. It is suggested that some of the items be made available in the classroom for those pupils who are unprepared.

2. Simple conductivity testers, required for the laboratory investigations, may be prepared following the illustration shown. Each group of pupils should receive one for performing the test. Show how they are to be used:



Summary

1. Prepare the following chart on the chalkboard. Use the data collected by the pupils to complete the chart.

ITEM TESTED	RED LITMUS	BLUE LITMUS	CONDUCTS ELECTRICITY	ACID, BASE OR NEUTRAL

2. Discuss the uses of each item which the pupils have tested.

Homework

1. Name 3 acids found in the home. What is each used for?
2. Name 3 bases found in the home. What is each used for?

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 25

Problem: What are some acids and bases found in the home?

Materials

Items brought from home
Red litmus paper
Blue litmus paper
Conductivity tester
4 beakers
Glass stirring rod
Medicine dropper

Procedures and Observations

1. Place each item to be tested in a separate beaker.
2. If the item is a solid, remember to add water before performing tests.
3. Record your observations on the chart as you perform each test.
4. Use the medicine dropper to place a few drops of the solution on the red and blue litmus paper.
5. If there is time, when you have finished testing all the items you brought from home, your teacher may permit you to borrow some solutions from your neighbors for further testing.

ITEM TESTED	RED LITMUS	BLUE LITMUS	CONDUCTS ELECTRICITY	ACID, BASE OR NEUTRAL

Conclusions

1. Acids turn____________________ litmus____________________.
2. Bases turn____________________ litmus____________________.
3. Acids and bases conduct____________________.
4. The following solutions were acids:
   a. ________________. b. ________________. c. ________________.
5. The following solutions were bases:
   a. ________________. b. ________________. c. ________________.

6. The following solutions were neutral:

a. ______________ . b. ______________ . c. ______________ .

---

26. HOW DO SALTS CHANGE THE ELECTRICAL PROPERTIES OF WATER?

LABORATORY LESSON

Outcomes

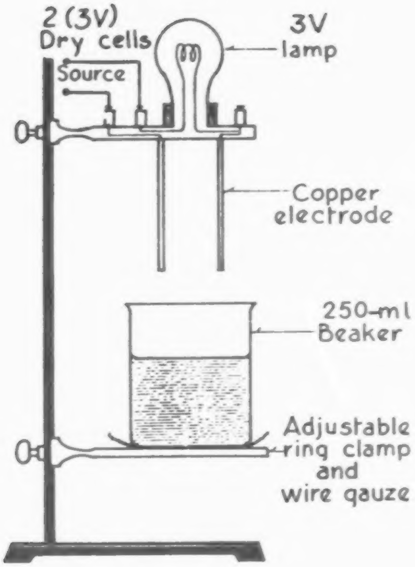
- The addition of salts to water allows the solution to conduct an electric current.
- Salts in the solid state do not conduct electricity.
- Sugar, either as a solid or in water solution, will not conduct an electric current.
- Solutions of salts are electrolytes.
- Some salts make better electrolytes than other salts.
- *Salts contain neither hydrogen nor hydroxyl groups.*
- *The action of water upon salts to form acidic or basic solutions is called hydrolysis.*
- *The electrical conductivity of a salt may be measured more accurately by using a voltmeter.*

Motivation

Ask the pupils to explain why it is dangerous to swim in salt water during an electrical storm. Ask, "Suppose this was distilled water, would it be equally dangerous to swim during an electrical storm?"

Development

1. Prepare conductivity tester as shown (next page): Review its use.
2. Distribute the materials and proceed with the laboratory lesson.
3. At the end of the lesson, list the salts (on the board) in order of conductivity.



3a. *Write on the board the chemical formula for the salts and elicit the fact that salts do not contain H^+ or OH^- groups. Guide the pupils to realize that the H^+ from the acid combined with the OH^- from the base to form the water.*

4. *Test the salt solutions with litmus paper. Make three columns on the chalkboard, one labeled "Acid Salt", another "Basic Salt", and the third "Neutral Salt". List the salts in the appropriate columns. Explain that the action of water upon salts to form acidic or basic solutions is called hydrolysis.*

5. *Set up the conductivity tester, but replace the electric light bulb with a voltmeter. Test each salt solution and record the number of volts conducted by each. Establish that this is a more accurate method than estimating the brightness of a lamp.*

Summary

1. Pure water__________conduct electricity.
2. When salt is dissolved in water, the water__________electricity.
3. A solution which conducts electricity is called__________.

4. **In addition to salts,____________ and ____________are also electrolytes.**

5. **If the lamp burns brighter, it means that the electrolyte is ____________.**

6. ***Salts do not contain____________ or ____________.***

7. ***What is meant by hydrolysis?***

8. ***Why is the voltmeter a better way of measuring conductivity than brightness of a lamp?***

Homework

1. Make a solution of table salt in water.
2. Cut a paper towel into 3 small pieces (about one inch on each side) and dip them into the salt water.
3. Take 4 pennies and place the wet paper between the pennies so you have a penny on bottom, then paper, then a penny, then paper, penny, paper and a penny on top.
4. Tape a piece of wire to the top penny and another wire to the bottom penny.
5. Connect the other ends of the pennies to a flashlight bulb. Does the light go on? Explain what happened.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — CHEMISTRY: LESSON 26

Problem: Will the addition of salts make water conduct electricity?

Materials

Conductivity tester
Five 250 ml beakers
Glass stirring rod
10 grams of sodium chloride
10 grams of powdered copper sulfate
10 grams of potassium permanganate
10 grams of ammonium dichromate
10 grams of sugar

Procedure and Observations

In testing for conductivity, (whether or not the light goes on) you will also compare the brightness of the light in the various solutions.

1. Pour 100 cc of water into a beaker and test it to see if it will conduct electricity.
   a. The light ____________________ go on.
   b. Water ____________________ an electrolyte.
2. Add sodium chloride to the water and stir. Test the solution for conductivity.
   a. The light ____________________ go on.
   b. Salt water ____________________ an electrolyte.
3. In a dry beaker, place the powdered copper sulfate. Test it for conductivity.
   a. The light ____________________ go on.
   b. Dry copper sulfate ____________________ an electrolyte.
4. Add 100 ml of water to the copper sulfate and stir it until it dissolves. Test the solution for conductivity.
   a. The light ____________________ go on.
   b. Copper sulfate solution ____________________ an electrolyte.
5. Repeat Steps #3, 4 and 5 for the potassium permanganate, ammonium dichromate and sugar.
6. Record your observation on the following chart:

   Number the substances tested in order of brightness (#1 is the brightest).

SUBSTANCE TESTED	DOES THE LAMP GO ON?	ELECTROLYTE NO ELECTROLYTE	BRIGHTNESS #1,2,ETC.
Sodium chloride solution			
Dry copper sulfate			
Copper sulfate solution			
Dry potassium permanganate			
Potassium permanganate solution			
Dry ammonium dichromate			
Ammonium dichromate solution			
Dry sugar			
Sugar solution			

7. In the sugar solution, the lamp ____________________ go on.
   This proves that sugar ____________________ an electrolyte.

Conclusions

1. Solutions of salts in water ____________________ (do, do not) conduct electricity.
2. Solid salts ____________________ (do, do not) conduct electricity.

3. Solutions which conduct electricity are called ______________.

4. All salts ______________ (do, do not) conduct electricity the same way.

27. WHY DO SOME SOLUTIONS CONDUCT ELECTRICITY?

Outcomes

- When a salt is dissolved in water, the molecules break up.
- The parts of the molecules are electrically charged.
- These charged particles are called ions.
- Acids and bases also dissociate to form ions.
- *Arrhenius' Theory explains ionization. The movement of ions, with the resultant transfer of electrons, constitutes an electric current flowing through an electrolytic solution.*

Motivation

Use sets of pith balls or plastic discs, as follows, to demonstrate that some molecules dissociate in water whereas some do not.

a. In advance, attach several pairs of pith balls or discs together with a water-soluble paste (i.e., flour). Do the same with other pairs, using an insoluble paste (airplane glue).

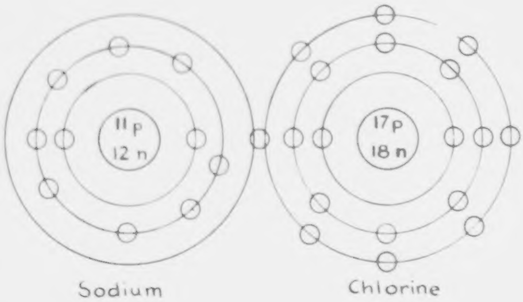
b. Explain that each pair of discs represents a molecule of a compound, each composed of 2 atoms. Ask, "What will happen if we drop these compounds into water?" Drop each pair into separate 500 ml beakers of water.

c. Guide the pupils to observe that one pair separates while the other does not. Ask, "What happens to some molecules of compounds when they are placed in water?"

Development

1. From the previous lesson, recall the fact that solid salt does not conduct electricity while a solution of salt does.

2. Elicit the formula for salt and write it on the chalkboard.
3. Recall the plastic disc demonstration and ask, "What happens to salt when we place it in water?"
4. Guide the pupils to understand that the salt molecule breaks apart much the same as the plastic discs separated.
5. Review the structure and particles of an atom (7th Grade Chemistry).
6. Draw the electron configurations of sodium chloride on the board.



7. Point out that this is electrically neutral (7th Grade Chemistry).
8. Using the diagram, show how the atoms dissociate in the water solution so that the chlorine atom takes an electron from the sodium atom. This causes the sodium (which has lost an electron) to be positively charged and the chlorine (which has gained an electron) to be negatively charged. Explain that such a charged atom is called an *ion;* therefore, the charged sodium atom is a positive ion, and the charged chlorine atom is a negative ion.

8a. Arrhenius was the first to explain ionization. He said an acid is a compound which breaks apart and forms H^+ *ions and a base forms* OH^- *ions.*

9. Go back to the sodium chloride formula (on the chalkboard). Write the equation for the dissociation:

   $NaCl \rightarrow Na^+ + Cl^-$
10. Lead the pupils to understand that these charged particles move about in the water, thus conducting an electric current.

11. Ask, "Do acids and bases behave the same as salts when they are placed in water?" Guide the pupils to conclude that they must dissociate the same way since they also conduct electricity.

12. *Set up an electric cell, using cupric chloride ($CuCl_2$) as the electrolyte. Write the equation for the dissociation on the chalkboard:*

$$CuCl_2 \rightarrow Cu^{++} + 2Cl^-$$

Lead the pupils to conclude that the copper ion is attracted to the negative electrode and the chloride ion is attracted to the positive electrode. This movement of ions accounts for the transfer of billions of electrons through the solution.

Summary

1. What happens to salt molecules when they are placed in water?
2. What is an ion?
3. What are the two kinds of ions?
4. What happens to a hydrochloric acid molecule in water? Write the equation.
5. Why doesn't a solution of sugar in water conduct electricity?
6. *How did Arrhenius describe an acid? A base?*
7. *How does a wet cell operate?*

Homework

1. What happens to a molecule of sodium hydroxide (NaOH) in water? Write the equation.
2. Why can solutions of acids, bases, and salts be used as electrolytes?

Materials

4 plastic discs or pith balls
Flour paste
Airplane glue
3 beakers of water
Conductivity of electricity tester
Salt crystals
Stirring rod

Copper electrode
Zinc electrode
Wires
Galvanometer
Beaker
Cupric chloride solution

AIR POLLUTION

Suggested Lessons and Procedures

28. WHAT ARE YOU BREATHING TODAY?

Outcomes

- Air contains many substances which are foreign to the air.
- Such substances are called pollutants.
- Pollution can be very harmful.
- *Radioactive fallout is a pollutant.*
- *Air pollution affects animals as well as humans.*

Motivation

Ask, "How many of you came to school by bus today? Where does the exhaust from the bus go?" Develop that there are many buses, trucks and automobiles in our city, all of which contaminate the air.

Development

1. Have pupils look about the room to examine the air for substances. Ask, "Can you see anything?" "Why?" Elicit that air is made up of gases which are invisible. Ask, "Is there anything else in the air which we are breathing?" Blow a small amount of chalk powder into the air, wait a few moments until the chalk dust is dissipated and elicit that we inhale substances in the air even though we

cannot see them. Ask them to explain why they may see the beam of light in a movie house mostly over the balcony area.

2. Have pupils recall that particles in suspension can be made visible, vary in size, and settle, if undisturbed. Elicit suggestions for testing air for the presence of suspended particles.

3. Direct a projector beam at a wall and have a pupil examine the beam for suspended particles. Elicit that suspended dust particles are visible and vary in size.

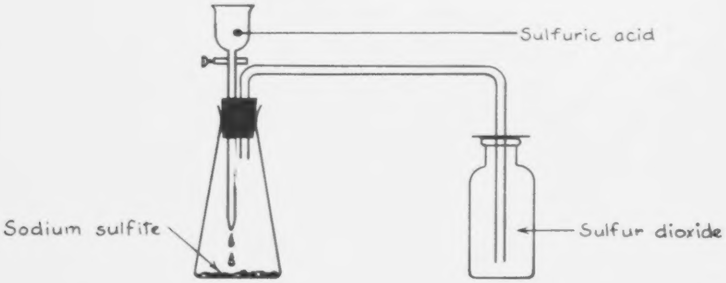
   Ask, "Do any particles settle out?" "Can you prove this?" Have a pupil wipe the windowsill with a damp tissue and display it to the class. Elicit that these particles settled out of the air in which they were suspended.

4. Introduce and define the term *pollutant*. Guide pupils to understand that pollutants may occur in any state: gas, liquid or solid. Have pupils make lists of pollutants in the three categories, such as:

SOLIDS	LIQUIDS	GASES
dust	fog	Sulfur dioxide
ashes	liquid sprays	Hydrogen sulfide
metal particles		Nitrogen dioxide
smoke from combustion		Carbon monoxide
tobacco smoke		

4a. *Discuss radioactive fallout such as Strontium-90 which is a universal pollutant and is found in New York. The amount varies with the number of explosions of atomic devices in the atmosphere and the amount of precipitation.*

5. Prepare sulfur dioxide using the setup shown:



Permit the sulfuric acid to enter drop by drop so that you do not produce an excess of sulfur dioxide. Guide the pupils to understand that sulfur dioxide is one of the pollutants of our air and that it is a colorless gas with a very sharp odor and very soluble in water. Exercise extreme care in permitting pupils to waft the odor toward themselves.

6. Ask, "What happens to the sulfur dioxide when it rains?" Remove the delivery tube and cover from the bottle (I) insert it into another bottle (II). Fill the collecting bottle (I) half full of water. Stopper it and shake. Remove the stopper and waft the air atop the bottle towards the pupils. Elicit that most of the gas dissolves in the water.

7. Ask, "How can we find out if the sulfur dioxide solution is an acid or a base?" Help the pupils to recall that they learned to test for acids and bases. Call a pupil to the demonstration table and have him test with litmus paper. Help the pupils to understand that sulfur dioxide is an irritating pollutant which in solution is an acid (sulfurous).

8. *Guide a discussion of other pollutants such as nitrogen dioxide and hydrogen sulfide which are poisonous in large amount and irritating in low concentrations. Ask, "Why does silverware tarnish?"*

9. Ask, "What parts of our body are affected most by air pollution?" Discuss possible effects on the lungs and circulatory system.

9a. *Help pupils to understand that air pollution has an effect on animals as well as on man. Dogs suffer in about the same degree as humans.*

Summary

1. A beam of light will show that__________particles are present in air.

2. Pollutants may be solids,__________ or __________.

3. An example of a gaseous pollutant is__________.

4. *A pollutant from atomic explosions is*__________.

5. *Two irritating pollutants are*__________ *and* __________.

Homework

1. Cut out a piece of white cardboard 1-inch wide and 2-inches long. Cover half the card with a thin layer of petroleum jelly (vaseline). Attach a paper clip to the uncovered part of the card. Put the card outside your window.

   Bring the card to school to compare the air pollution in various neighborhoods.

2. In what way is air pollution harmful?

3. *Keep a record of the amount of pollution as reported in the New York Times or other sources and report your findings.*

Materials

Chalk dust
Erlenmeyer flask (2)
Collecting bottles (2)
Cardboard cover with hole in center
Sulfuric acid
Sodium sulfite
Two-hole rubber stopper fitted with a dropping funnel and delivery tube as in diagram

Enrichment

Compare air pollution in New York City with that of other cities. Investigate U.S. Public Health Service and other reports.

Note that on August 3, 1967, the Public Health Service stated that New York City ranked highest for air pollution of 65 urban centers. Ratings were based on: average total of air pollution particles in the atmosphere; frequency and severity of excessive air pollution episodes; the area's total gasoline consumption; the population density of automobiles; the average concentration of sulphur dioxide in the atmosphere; the area's total emission of sulphur dioxide; and other factors.

Comparison may also be made of different types of air pollution (i.e., the oxidizing type in New York, and the reducing, photochemical smog, in Los Angeles).

29. WHAT CAUSES AIR POLLUTION, AND WHAT CAN WE DO ABOUT IT?

Outcomes

- Common causes of pollution are:
  - burning fuel in furnaces
  - burning fuel in vehicles
  - smoking
- Pollution may be minimized by
  - use of different fuels
  - use of atomic energy
  - use of electric engines
  - elimination of smoking
- *A temperature inversion creates a hazardous pollution situation.*

Motivation

Ask, "How many pounds of dust fall on New York City every day?" List pupils' guesses, and then supply the correct answer: 1,280,000 pounds.

Development

1. Ask, "Have you seen any chimneys giving off heavy smoke lately? Why don't all furnaces give off heavy smoke?" Elicit that there are three kinds of fuels: gas, oil, and coal; and that there are two kinds of coal called soft coal and hard coal. Display samples of soft and hard coal. Help pupils to understand that soft coal is cheaper but produces a thick smoky flame. Demonstrate soot formation when a candle burns (catch the "smoke" on a glass plate). Ask, "What can be done to have less soot from smoke?" Elicit that the use of fuels that produce less smoke is one answer (for example, heating by gas or electricity).

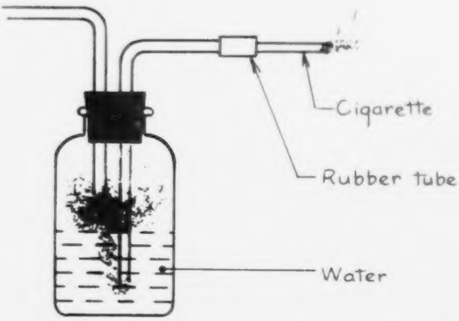
2. Ask, "How do cars, trucks, and buses pollute the air?" Elicit that the exhaust of these vehicles contains many harmful gases including the very dangerous carbon monoxide which unites with the blood and doesn't allow it to carry oxygen. Ask, "Are there any ways of

solving this problem?" Discuss faulty engine or exhaust systems in cars, and possible inspections. Elicit that traps, burners and other devices are being tried. Have a pupil tell how an electric car would solve this problem.

3. Ask, "How is Con Edison helping to solve the pollution problem?" Help pupils to understand that to produce electricity we must turn coils in a generator and that the force to do this usually has to come from burning coal. Some of the pupils may have seen the generating stations along the East River. Ask, "What kind of energy does Con Edison use in its new stations?" Elicit that the power in the new stations comes from a nuclear reactor and there is no pollution at all.

3a. Ask, "How would stationary air aggravate the pollution problem?" Help pupils to understand that a special condition called a temperature inversion (a cooler layer of air is below a warm layer of air and normal convection currents do not occur) causes an accumulation of pollutants.

4. Make the pupils aware that an average adult male needs 2¾ pounds of food per day, 4½ pounds of water and 30 pounds of good clean air. Ask, "How do many people pollute the air which they breathe?" Elicit that smokers add new pollutants to the air which they and others breathe. Use the setup shown to draw cigarette smoke through the water.



Relate to the Turkish water pipe as a way of removing various substances.

Pass the solutions among the pupils for inspection and lead them to understand that these kinds of pollutants are trapped in the moisture of the lungs.

5. "How does garbage disposal pollute the air?" Discuss the burning of garbage in dumps, the use of fill, and the use of incinerators in buildings. Elicit that pollution would be less if we used other methods of garbage disposal (i.e., chemical breakdown) and placed filters and brushes in connection with incinerators.

Summary

1. ____________coal produces more smoke than____________coal.
2. A very dangerous gas is____________.
3. This gas can be found in the exhaust of____________.
4. This gas doesn't permit blood to carry____________.
5. Electricity can be produced without pollution by using____________ energy.
6. Pollutants from cigarettes are trapped in the____________.
7. *What is a temperature inversion?*
8. *How does this cause a pollution problem?*

Homework

1. On the way home tomorrow, watch for things which pollute the air. Make a list of what you have seen.
2. Weigh a small jar. Every day brush the dust from a window sill into the jar. After one week, weigh the jar and report your findings.
3. *What is New York City doing to make our air cleaner?*

Materials

Wide-neck bottle
Cigarette
Candle
Glass plate
Two-hole stopper fitted with glass tubing as in diagram
2″ length of rubber tubing

Appendix

SUGGESTED REFERENCES

For the Teacher

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ENRICHMENT ACTIVITIES

Subject Matter

1. How can pollutants be removed from the air?
2. What pollutes our water supply?
3. How can industrial pollutants be removed from water?

Pupil Projects

1. Crystal growing
2. Investigate different kinds of paints and their solvents.
3. How is photographic paper made?
4. How are prints made from negatives?
5. How are blueprints made?
6. How does a septic tank operate?
7. Investigate effervescent and deliquescent substances.
8. How can chromotography be used in the separation of mixtures?

Trips

1. Hall of Science
2. Museum of Natural History
3. Union Carbide Company
4. Allied Chemical Company

Research

1. Report on pollution hazards for workers in various industries.
2. How are detergents made? How do they work?
3. Investigate the refining of crude oil and the products obtained.
4. What acids and bases are found in the human body? What do they do?
5. What is the Bronsted theory?
6. What is the Lewis theory?
7. Investigate colloidal systems in the body.
8. How much material which is in seawater is present in solution?

TEST QUESTIONS

Multiple Choice

Write the letter of the correct answer in the space at the left.

__________ 1. An example of a mixture is

a) sodium chloride
b) sea water
c) oxygen
d) water vapor

__________ 2. Particles of solute in a solution

a) are visible to the unaided eye
b) do not pass through the filter
c) settle to the bottom
d) are molecular in size

__________ 3. A solution is

a) homogeneous
b) homogenized
c) cloudy
d) always colorless

__________ 4. Solvents may be

a) solids
b) emulsions
c) any liquids in which a solute dissolves
d) solutes

__________ 5. If one gram of salt is dissolved in 1000 ml. of water, the resulting solution will be

a) concentrated
b) dilute
c) saturated
d) supersaturated

__________ 6. Heating a solution will cause
a) no solute to dissolve
b) particles of solute to evaporate first
c) more solute to dissolve
d) a drop in temperature

__________ 7. A solution which can no longer dissolve the solute added at a given temperature is
a) hot
b) concentrated
c) saturated
d) dilute

__________ 8. A solid dissolved in alcohol forms a
a) tincture
b) emulsion
c) suspension
d) crystal

__________ 9. Nail polish remover is able to clean fingernails because it:
a) bleaches the nails
b) evaporates the polish
c) forms a tincture
d) dissolves the polish

__________10. A crystal face is
a) rough
b) clear
c) always invisible
d) smooth

__________11. The conditions which speed up the formation of a solution are
a) powdering the solute
b) stirring the solution
c) heating the solvent
d) all of these

__________12. Crystals
a) have an orderly arrangement of atoms
b) are usually hexagonal
c) form in a dilute solution
d) all of these

__________13. A gas can usually be changed back to a liquid by
a) heating
b) evaporating
c) cooling
d) purification

__________14. The electrical conductivity of a concentrated acid will increase if you

a) add more concentrated acid
b) add salt
c) add water
d) use thinner wires

__________15. When sodium chloride is dissolved in water

a) it does not conduct electricity
b) three kinds of ions form
c) only positive ions form
d) two kinds of ions form

__________16. An ion is a kind of atom which

a) always has a charge
b) has the same number of protons as electrons
c) has no charge
d) is always negatively charged

__________17. The heat of fusion of a substance is heat needed to

a) increase the size of molecules
b) change the distance between molecules
c) decrease the speed of molecules
d) change a solid to a liquid

__________18. The ion which always forms when acids ionize is

a) Cl^-
b) SO_4
c) Na^+
d) H^+

__________19. The first-aid treatment for an acid burn on the skin is to wash with water and then apply

a) salt
b) sodium hydroxide
c) sodium bicarbonate
d) vinegar

__________20. The ion which always forms when bases ionize is

a) Na^+
b) OH^-
c) H^+
d) Cl^-

Completion

Write the word or expression that best completes the statements.

1. Stirring makes particles__________faster.
2. The particles of a solute in solution are too__________to be seen.

3. To freeze water we must remove____________.

4. The temperature at which boiling starts is called the ____________.

5. Dissolved solids raise the____________of water.

6. Water freezes at____________°C.

7. On the freezing point curve the flat portion shows that the temperature is____________.

8. A solute cannot be removed from solution by____________.

9. The process of changing a liquid into a gas is called____________.

10. When a supersaturated solution is seeded, the solute____________.

11. If the particles in a liquid are visible then it is a____________.

12. In fractional distillation of petroleum, gasoline distills first because____________.

13. During centrifugation, particles are separated from a liquid by ____________.

14. Fat globules in milk are broken up and suspended by the process called____________.

15. Hydrochloric acid may be neutralized by adding____________.

16. When a solution contains as much solute as it can hold, it is a ____________solution.

17. In order for liquids to boil,____________must be added.

18. When a solute is added to water, the boiling point of the water ____________.

19. Additional heat which is added after boiling starts is called ____________.

20. When evaporation is followed by condensation, the process is called____________.

Matching

Fill in the letter of the word or words in Column II which best match the statement in Column I.

COLUMN I	COLUMN II
_____ 1. homogeneous	a. a liquid which dissolves
_____ 2. soluble	b. clearness
_____ 3. miscible	c. water
_____ 4. solute	d. small amount of solute
_____ 5. solvent	e. spread out evenly
_____ 6. transparent	f. opaque
_____ 7. clarity	g. no more solute can dissolve
_____ 8. dilute	h. molecular size
_____ 9. concentrated	i. emulsion
_____10. saturated	j. large amount of solute
	k. can be dissolved
	l. light passes through

COLUMN I	COLUMN II
_____ 1. freezing point	a. water escapes from solution
_____ 2. heat of fusion	b. water turns to ice
_____ 3. boiling point	c. settling out
_____ 4. heat of vaporization	d. steam turns to liquid
_____ 5. evaporation	e. passing through a filter
_____ 6. condensation	f. adding chlorine
_____ 7. distillation	g. 32°F
_____ 8. sedimentation	h. water turns to steam
_____ 9. filtration	i. adding air to water
_____10. coagulation	j. Liebig condenser
	k. makes suspended particles larger
	l. 100°C

COLUMN I	COLUMN II
_____ 1. crystal	a. reflects light
_____ 2. supersaturated	b. semi-solid
_____ 3. suspension	c. adding air to water
_____ 4. emulsion	d. oil in water
_____ 5. colloid	e. alcohol
_____ 6. centrifuge	f. kills germs
_____ 7. gel	g. orderly arrangement of atoms
_____ 8. aeration	h. filtration
_____ 9. chlorination	i. fog
_____10. emulsifying agent	j. soap
	k. outward force
	l. more solute than is dissolved

Column I

______ 1. acid
______ 2. base
______ 3. litmus
______ 4. electrolyte
______ 5. salt
______ 6. ion
______ 7. neutral
______ 8. electricity
______ 9. dissociation
______10. hydrolysis

Column II

a. indicator
b. product of neutralization
c. neither acid nor base
d. action of water on salt
e. flow of electrons
f. turns blue litmus red
g. molecule separates into atoms
h. tastes sweet
i. conducts electricity
j. charged atom
k. non-electrolyte
l. turns red litmus blue

Essay

1. Compare a solution with a suspension.
2. What are some methods of speeding up solution, and explain why they work?
3. How can solutes be removed from solution?
4. How can solvents be removed from solution?
5. What are the methods of purifying water? Explain each.
6. What are acids and bases, and how can they be recognized?
7. What happens when an acid is mixed with a base?
8. What are electrolytes, and how do they work?
9. What are some causes of air pollution?
10. What are some ways of preventing air pollution?

Reasoning

Give a reason for each of the following:

1. A mixture of ice and water remains at the same temperature until all the ice has melted.
2. Boiling soup will cause a burn worse than that from boiling water.
3. Quiet ponds have clear water.

4. A bottle of salad oil is shaken before it is used.
5. Salt water conducts electricity.
6. The use of atomic energy will help to solve the air pollution problem.
7. A beam of light can be used to show whether a liquid mixture is a solution or a suspension.
8. Water evaporates faster when it is warm than when it is cold.
9. A centrifuge separates suspended particles from the liquid.
10. Citrus fruits have a sour taste.
11. Soft coal should not be used as a fuel.

Unit II

PHYSICS

Energy

Force and Work

Machines

Density and Pressure

ENERGY

Suggested Lessons and Procedures

1. WHAT ARE THE DIFFERENT FORMS OF ENERGY?

Outcomes

- Streams, wind, and running water have energy. This is called mechanical energy.
- Other forms of energy are: chemical, electrical, atomic, heat, light, and sound.

Motivation

By asking a question such as, "How did you get to school this morning?", elicit that muscles move arm and leg bones permitting us to walk, electricity makes our subways move, gasoline or diesel engines power our buses.

Development

1. Construct the following apparatus before the lesson:
   - a. Cut off the raised portion of an aluminum pie pan.
   - b. Form the remaining disc in the following manner:
     Cut along solid lines.
     Fold along dotted lines so that the folded section is perpendicular to disc.
   - c. Using a thumbtack, mount the pinwheel to the flat end of a dowel. (Thumbtack must pass through center of pinwheel.)
   - d. Assemble the following:

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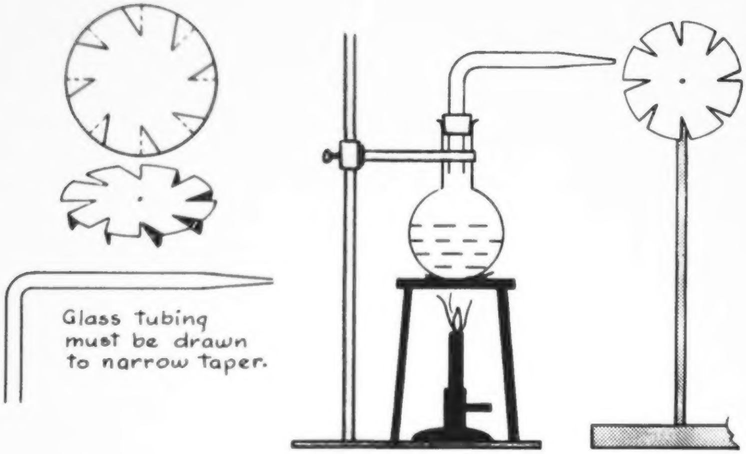


2. Demonstrate an example of mechanical energy by having pupils observe the effect of steam on the pinwheel. Encourage pupils to suggest what made the pinwheel turn. Elicit that the steam caused the pinwheel to turn.

   Now have a pupil blow on the turbine (pinwheel). Have the class observe that moving air causes the turbine to move.

   Have another pupil direct a flow of water on the turbine. Have the class observe the results.

   Identify all of the above as examples of *mechanical energy.*

3. Demonstrate *electrical energy* by having a pupil crank the hand generator. Elicit that this is electrical energy by asking, "Why does the light bulb glow?"

4. To introduce the concept of *atomic energy,* the teacher may discuss briefly some of the following: atomic bomb, the sun, nuclear powered subs, Con Ed nuclear reactors, etc.

5. To demonstrate *heat energy,* have the students rub their hands together briskly. Ask what kind of energy is being produced.

6. A radiometer held in sunlight will demonstrate the effect of *light energy* on the vanes.

7. *Chemical energy* may be shown by adding a small amount of dilute hydrochloric acid to a few marble chips in a 250 ml beaker. By

observing the bubbling, guide pupils to identify this as a release of chemical energy.

7a. *Challenge the pupils to suggest ways to identify the gas being produced* (CO_2)*. Have materials available to test for* O_2, H_2 *and* CO_2 *(use limewater and/or brom-thymol blue).*

8. Striking a tuning fork, elicit that *sound energy* is being produced.

Summmary

1. What are the different forms of energy?

2. What kinds of energy do liquids and gases in motion produce?

Homework

Fill in the following table:

Form of energy	Example	Use
1.		
2.		
3.		
4.		
5.		
6.		
7.		

Materials

Aluminum pie pan
Scissors
3″ dowel
Thumbtacks
Glass tubing
Bunsen burner
Tripod and wire gauze
Dilute HCl

2 ring stands with clamps
250 ml flask with 1-hole rubber stopper
Hand generator
Radiometer
250 ml beaker
Marble chips
Tuning fork

Limewater
Brom-thymol blue

2. HOW DOES ENERGY CHANGE?

Outcomes

- Energy can be changed from one form to another.
- Energy changes are called conversions.

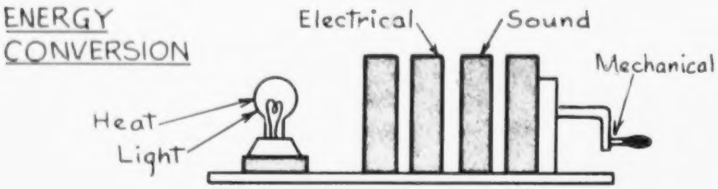
Motivation

Blow up a paper bag and burst it with your fist.

Challenge the class with the question "Where did the sound energy come from?"

Development

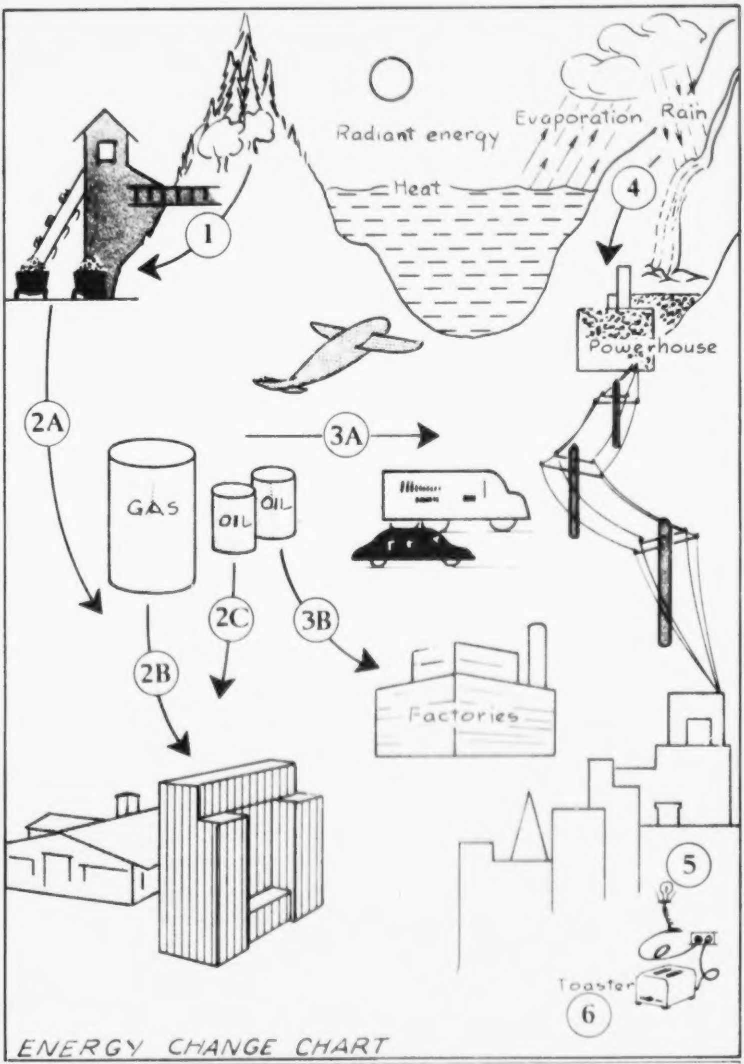
1. Have a pupil turn the hand generator and have the class write down all the forms of energy being produced. The following diagram may be helpful.



1a. Prepare two test tubes as follows: Place 4 cc of 2%$AgNO_3$ with 4 cc of 5% NaCl solution in each of two test tubes. Place one test tube on the windowsill in direct sunlight and place the other in a dark place. (If no sunlight is available, place in strong artificial light.) After five minutes, ask pupils to explain the reaction in the exposed tube.

2. Based on demonstration ask "Where are all the different forms of energy coming from?" Define the expression *"energy conversion"* to mean "change of energy from one form to another."

2a. Challenge pupils to explain the relationship between the electrical energy produced by running water (waterfalls) and the energy received from the sun.


Radiant energy
Evaporation
Rain
Heat
1
4
Powerhouse
2A
3A
GAS
OIL
OIL
2C
3B
2B
Factories
5
Toaster
6

ENERGY CHANGE CHART

ENERGY CHANGE TABLE

	From	To		From	To		From	To
1			2C			4		
2A			3A			5		
2B			3B			6		

3. Show the class a flashlight and challenge them to trace the energy conversions starting with the dry cells and ending with the light bulb.

3a. Review chemical reaction of dry cell. Refer to Physics 7 unit-electricity.

4. Distribute the energy change chart (on the next page) and discuss this with the class. (Completion to be assigned as homework.)

Summary

1. From where do the different forms of energy come?
2. What energy conversion takes place when a dry cell is used?

Homework

1. When you strike a match, what energy conversions are taking place?
2. What energy conversions take place when a car is started?
3. Complete the energy change chart.

Materials

Hand generator
Flashlight
2 D cells
Energy change chart (to be duplicated in advance)

Dissected dry cell
5% NaCl *solution*
2% $AgNO_3$ *solution*
2 *test tubes*
Test tube rack

3. WHAT HAPPENS TO ENERGY AFTER IT IS USED?

Outcomes

- The energy wasted in machines is converted into heat energy.
- Energy cannot be destroyed; only changed from one form to another.

Motivation

Crank the hand generator with the bulb in place. Repeat this procedure after removing the bulb. Pose the following question, "What happened to the energy that lit the bulb?"

Contrast the different amounts of heat energy wasted by allowing fluorescent and incandescent bulbs to remain lit for several minutes. Have the class make predictions and have a pupil confirm the results.

Development

1. Have a pupil inflate a basketball with a hand pump. After a moment, ask the pupil to describe to the class what is happening to the pump. (It is warmer because of the effects of friction.)

1a. "What machines not designed to give off heat, do so when they operate?" "How do engineers overcome this problem?"
—use of motor oil in automobile engines
—radiators in automobiles
—open back on radio and TV (heat louvres)

NOTE: *Transistors waste very little energy. Thus they have helped overcome the heat problem in electronic equipment.*

2. Ask a pupil to break a thin metal strip by repeated bending. Have the pupil report his observation.
3. Have a pupil sandpaper a block of wood and report his observations to the class.
4. Develop the concept that wasted energy is being given off as heat. Ask questions such as:
   a. "Is the heat helping the machine do its work? Explain."
   b. "How could we make the bicycle pump work better?"
   c. "What kind of energy is being wasted in the bicycle pump?"

Summary

"Where has the energy gone in all experiments completed thus far?" Guide the pupils to the generalization that energy is never destroyed, only changed in form.

Repeat motivational procedure and ask: "What happened to the original energy that lit the bulb?"

Homework

1. Of the following machines, which:
   a. use the heat produced?
   b. waste the heat produced?
   c. use and waste heat produced?

	USE	WASTE	BOTH
Toaster			
Elec. shaver			
Bicycle pump			
Fan			
Automobile			

2. A fluorescent bulb stays cool when it is lit. An incandescent lamp (ordinary light bulb) gets hot. Which one wastes more energy? How can we tell?

3. *After being lit for 10 minutes, it is observed that a 40 watt fluorescent bulb is cool while a 40 watt incandescent bulb is hot. Which bulb should give off more light? Why?*

Materials

Hand generator
Hand pump
Block of wood

Basketball
6" x 1" metal strip
Sandpaper

40W incandescent lamp
40W fluorescent bulb

3A. HOW CAN LIGHT ENERGY BE CHANGED INTO ELECTRICITY?

ENRICHMENT LESSON — OPTIONAL

Outcomes

- Light energy may be changed directly into electrical energy.
- The emissions of electrons by a surface when it is illuminated is called the *photoelectric effect.*

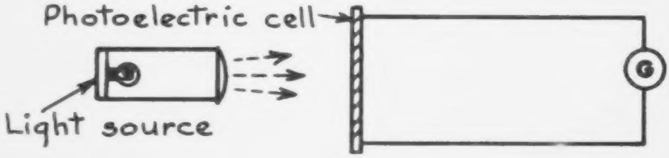
Motivation

Energy in the form of sunlight is free to all people. Wouldn't it be wonderful if this energy could be put to work in a different form?

NOTE: Assembly program on photoelectric effect is available from Bell Telephone.

Development

1. Exhibit a photoelectric cell attached to a galvanometer:



2. Shine a light on the photocell and have the class observe the galvanometer reading. Elicit that this is the direct conversion of light to electricity. Define this as the *photoelectric effect*.
3. Investigate the operation of the photoelectric cell to show that the amount of electricity produced is related to the amount of light that falls on the cell.
4. To have the pupils achieve an understanding of how the cell operates develop the following:
   a. Electric current is a flow of electrons or moving electrons. (Refer to *Physics, Grade* 7).
   b. Light is composed of small particles called photons.
   c. All matter is made up of atoms and all atoms have electrons associated with them.
5. Based upon the above, propose the following explanation to the class. When a photon of light collides with one of the electrons associated with an atom in just the right way, it may cause that electron to move. Moving electrons are called electric current and so light is changed to electricity.
6. Explain that some materials such as Selenium and Cesium have a larger photoelectric effect than other materials.

7. Have the class propose the possible uses, advantages and disadvantages of the photoelectric cell. Some of the following may be cited:
    a. source of electricity in satellites
    b. operation of relays to open doors
    c. burglar alarms
    d. automatic control of highway lights

Summary

1. What is the photoelectric effect?
2. Of what small particles is light composed?

Homework

1. Write an explanation of the photoelectric effect.
2. Design a burglar alarm that uses a photoelectric cell (electric eye).
3. Who was the man who best explained the photoelectric effect?

Materials

Light source	Photoelectric cell
Galvanometer	Wire

4. CAN ENERGY BE CREATED?

LABORATORY LESSON

Outcomes

- Energy can neither be created nor destroyed, only changed from one form to another.

Motivation

It is suggested that this lesson be introduced with the statement of the law. This should be placed on the chalkboard as a hypothesis to be tested. Challenge pupils to think through the meaning of the statement.

Development

1. Distribute materials to students.
2. The procedures to be followed are outlined on the Laboratory Worksheet. Guide the pupils in reading and understanding the procedure in the laboratory investigation.

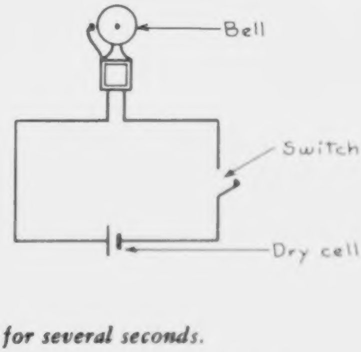
Based on the discussions and the laboratory experiences, guide the pupils in exploring and tracing the energy changes that are involved in making electricity, ringing a bell, lighting a fuel, etc.

Homework

1. Complete Worksheet.
2. Answer summary questions.
3. Write a laboratory report based on this lesson.
4. For extra credit, prepare a report on an experiment you did at home which shows application of the Law of Conservation of Energy.

Enrichment

As an additional laboratory activity, the pupils may set up the following circuit:



Close the switch for several seconds.

1. *What energy changes have taken place?*
2. *Is any heat produced?*
3. *Was any energy created?*

Materials (for enrichment)

Bell
Switch: single pole, single throw
Dry cell
Wire

(May be duplicated for use by pupils)

LABORATORY WORKSHEET — PHYSICS: LESSON 4

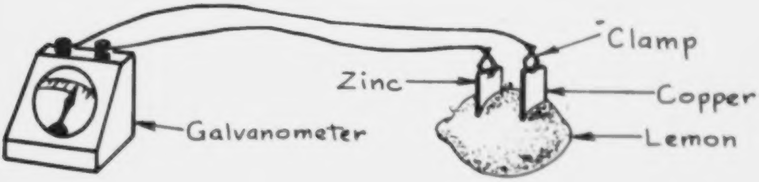
Problem: Can energy be created?

Materials

Alcohol lamp
Matches and/or striker
Fresh lemon
Galvanometers
Copper and zinc strips
Wire
Alligator clamps
Screwdriver

Procedure and Observations

1. Light the alcohol lamp.
   a. What energy changes cause the wick to burn?
   b. What energy changes are taking place?
   c. Was any energy created? If so, where?
2. Set up a Voltaic cell as shown:



   a. What kind of energy is being produced?________________
   b. Is any energy being created? If so, where?________________

Summary

1. Name two liquids other than alcohol that can be burned for energy.
   ____
2. If a bell rings for a long period of time, where will heat energy be produced?________________
3. Is the heat energy in question 2 useful or wasted?________________
   Explain.________________.

4. From where does the lemon itself get its energy? ____________________

5. Based upon your knowledge and your observations of the laboratory experiments, what 2 things have been verified about energy?

   a. Energy can never be ____________________.

   b. Energy can never be ____________________.

6. State the principle of *conservation of energy.* ____________________.

5. *HOW DOES THE ELECTRICAL FUSE MAKE USE OF ENERGY CONVERSIONS?

LABORATORY LESSON

Outcomes

- Energy exists in many forms.
- Energy may change from one form to another.

Motivation

Show the class a burned-out fuse. Challenge them to explain how the fuse used energy changes to do its job.

Development

1. Distribute Worksheets and materials.
2. Read the instructions with the class and aid them in the construction of the model fuse.
3. Allow the class time to complete the exercise and then discuss the results using the summary questions as a guide.
4. Have the class answer the review questions.

Summary

See Worksheet. Trace the changes in energy from the battery to the fuse model.

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* Only for classes programmed for five periods

Homework

1. Complete the review questions.
2. Write up the experiment.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 5

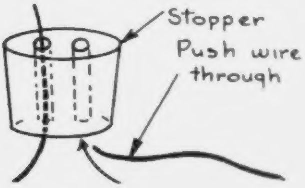
Problem: How does the electrical fuse make use of energy changes?

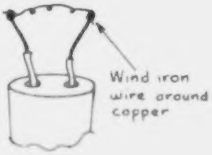
Materials

Cork with two small holes	Insulated copper wires
Iron wire (from steel wool pad)	Knife switch (single pole, single throw)
Dry cell	

Procedure

1. Construct the model as follows:


Stopper
Push wire through


Wind iron wire around copper

   a. Insert the insulated copper wires through the cork.

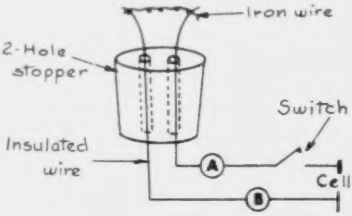
   b. Carefully wind iron wire around the exposed ends.

   c. Attach wire *A* to the dry cell (either terminal).

   d. Attach wire *B* to terminal of switch.

   e. Attach lead wire from switch to cell.

   NOTE: Switch is to be kept open.


Iron wire
2-Hole stopper
Switch
Insulated wire
A
Cell
B

2. With apparatus assembled, observe what happens to the iron wire when switch is closed.
3. Record your observations.

Summary

1. List all the forms of energy observed in the fuse setup. ______________________________

2. Does the fuse use or waste the heat produced? Explain. ______________________________

3. Why is the production of heat important in a fuse? ______________________________

4. How does the fuse show the concept of conservation of energy? ______________________________

Review

1. Complete the following table

	CHEM.	ELEC.	HEAT	LIGHT	MECHANICAL
Chemical	—				
Electrical		—			
Heat			—		
Light				—	
Mechanical					—

2. In what form is most wasted energy released from a machine? ______________

3. Based upon what you have learned about conservation of energy, answer the following statements *true* or *false*
   - a. The amount of energy in the universe is increasing. ____________
   - b. There is less energy in the universe now than there was 20 years ago. ____________
   - c. A gasoline engine does not create energy. ____________
   - d. Energy is destroyed in a fire. ____________
   - e. The total amount of energy on the universe is always the same (constant). ____________

FORCE AND WORK

Suggested Lessons and Procedures

6. WHAT IS A FORCE?

Outcomes

- A force is a push or a pull.
- In the English system, forces are measured in pounds and ounces.
- Forces can be measured with spring scales.

Motivation

Blow up a balloon. Ask the pupils what causes the balloon to become inflated. Elicit that the force of the air inside the balloon keeps it inflated. Release the balloon and ask what causes the balloon to move forward.

Development

1. Have a pupil sit in a chair at the front of the room. Ask the class how you might move the pupil and chair across the room. Lead the class to the conclusion that no matter how he is moved, a push or pull is involved.

1a. Ask the class how the amount of force required might be decreased. Elicit use of wheels, highly polished surface, etc.

Relate to friction and the heat that results as being wasteful.

2. Have a pupil write his name on the chalkboard. Ask him to re-

write his name, darker. Have him report to the class what it was necessary to do to write darker. The word *force* should be suggested.

3. Have a pupil tear apart a piece of paper. Have the class identify the pull as a form of force.
4. Challenge the pupils to identify any force that is not a push or pull or any push or pull that is not a force.
5. After they have seen that this is not possible, conclude with the generalization that a force is a push or pull.
6. Have a pupil lift an object of undetermined weight, using a spring scale. Ask him to determine the amount of force required to lift the object by reading the scale.
7. Establish the fact that in the U.S., forces are measured in pounds and ounces.

7a. Discuss the standards of weight measurement, tying in with mathematical learnings.

8. By having the pupil examine the scale, have him conclude that 16 ounces equal 1 pound.
9. Have several volunteers weigh objects of undetermined weight. Have them record these weights as pounds and fraction of the pound rather than ounces.

   Example: 12 oz. = .75 lb. = ¾ lb.

Summary

1. In what way does the air in the balloon keep the ballon inflated?
2. What are all pushes and pulls called?
3. What instrument is used to measure a force?
4. Calculate the number of pounds in 48 ounces.

4a. Calculate the number of pounds in 72 ounces.

Materials

Balloon
Spring scale — calibrated in pounds and ounces
Object of unknown weight

Homework

1. Fill in the following table by identifying the push or pull.

Example	Push	Pull	Cause
Inflated bicycle tire			
Falling rock			
Stretched rubber band			
Windmill			

2. *Assign pupils to report on Newton and the discovery of the Universal Law of Gravity.*

Enrichment

Teacher may wish to extend concepts of measurement as listed:

Power of ten	Prefix	Symbol
million	mega	M
thousand	kilo	k
hundred	hecto	h
ten	deca	da
one-tenth	deci	d
one-hundredth	centi	c
one-thousandth	milli	m
one-millionth	micro	μ (Greek letter mu)

7. HOW CAN A SPRING BE USED TO MEASURE FORCE?

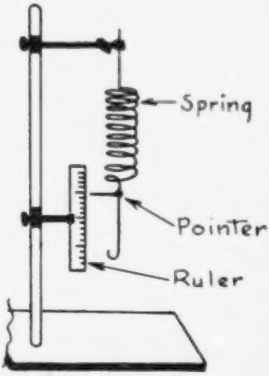
Outcomes

- The stretch of a spring is proportional to the weight suspended from it.
- In the metric system forces are measured in kilograms and grams.

Motivation

Note: Motivational demonstration must be set up before class enters and the spring constant determined.

1. Construct the apparatus as shown:



By determining beforehand the spring constant (distance spring will stretch with a one-gram weight), the teacher will be able to predict the amount of stretch for any gram weight within the elastic limit of the spring.

2. Stimulate pupil reaction by stating, "I can predict how far this spring will stretch for any combination of these weights." "How do you think it can be done?"

Development

1. Distribute rulers calibrated in the English and the metric systems. Have students identify differences and indicate the relationships between units. (1" equals 2.5 cm)

1a. Hand out metersticks and yardsticks to class. Have class develop the relationship between them. (1 meter = 39.37 in.)

2. Develop the understanding of feet and pounds as English units of measurement, and *centimeters* and *grams* as *metric* units.

2a. Establish that there is a similar relationship between grams and pounds.

1,000 gms = 1 kilogram
= 2.2 lb.

"How many grams are there in 1 lb."?

3. Refer to motivational demonstration by having a pupil place a 100-gram weight on the spring and record his observation on the chalkboard. Use the following table:

WEIGHT IN GRAMS	STRETCH IN CENTIMETERS

4. Repeat this procedure using 100 gram units.
5. Have pupils summarize with: "The amount of stretch on the spring is directly related to the number of grams placed on it."

5a. Discuss Hooke's Law and a determination of the spring constant for the spring being used.

6. Graph data from step 3 may be developed to show the linear relationship between weight and stretch.

Summary

1. When weight is measured in grams, what is length measured in?
2. How was the teacher able to predict how much the spring would stretch for different weights?

Homework

1. How many centimeters are there in twelve inches?
2. Draw a labeled diagram of the spring scale used in class today.
3. Fill in the following table:

WEIGHT IN GRAMS	STRETCH IN CENTIMETERS
100	10
200	
300	30
400	
	50

4. The spring scale used in class today could have been constructed without using a ruler. Explain.

Materials

Ring stand
2 clamps
Rulers
Spring scale
Metersticks
Yardsticks
Assorted gram weights

8. WHAT IS WORK?

Outcomes

- Work can only be done when the force on an object causes motion.
- The work done can be found by multiplying the force by the distance moved. (Work = Force × Distance)

Motivation

1. Evacuate the Magdeburg hemispheres. Have two pupils attempt to separate them. For the sake of safety, have a student stand behind each to prevent falling.
2. Allow air to enter the hemispheres and have two pupils attempt to separate them. Again, have a student stand behind each. Ask, "Who did more work?"

Development

1. Ask a pupil to push an immovable object such as the lab demonstration table.

1a. Challenge the class to cite instances where an object is moving, but no work is being done.
Examples: satellites, earth in orbit

2. Have another pupil move an easily moved object, such as a desk. Ask, "Who did more work?"
3. Based on the class response the teacher should develop, "Even though it appears that the pupils who could not move the table, or separate the hemispheres, were doing more work, no work was actually being done." Tell the class that the pupils who separated the hemispheres did work.

4. To elicit the difference between those cases in which work was done and those in which no work was accomplished, the following chart should be developed at the chalkboard, with the pupils:

HEMISPHERE OPENED DESK MOVED	HEMISPHERE NOT OPENED DESK NOT MOVED
Energy was used	Energy was used
Force was exerted	Force was exerted
Objects moved	Nothing moved
Work was done	No work was done

5. Based on above chart, have class conclude that for work to be accomplished a force must be exerted, and the object must move.

5a. Refer to the unit on energy. Indicate to the class that energy may be defined as the ability *to do work.*

6. Introduce, on the chalkboard, the statement: *Work* equals force times distance as a definition of work in physics.

7. Refer back to the table to verify W = FD as a description of work.

Summary

1. A man pushes a car for five minutes. The car does not move although he uses a lot of energy. How much work has he done? Explain.
2. *What are the two components of work?*

Homework

1. What two things are necessary for work to be done?
2. Write the formula for work.
3. How much work is being done to hold up the Empire State Building?

Materials

Magdeburg hemispheres	Vacuum pump

9. HOW CAN WE MEASURE WORK?

LABORATORY LESSON

Outcomes

- Work is done when an object is moved over a distance.
- When an object is rolled, less force is used than when it is dragged, and less work done.

Motivation

A man can push a car weighing 3,000 pounds, but he cannot lift it. Why?

Development

1. Distribute Worksheets.
2. Using a spring scale, ruler, and an object of unknown weight, illustrate for class how work is calculated.
   a. Lift the object 40 cm using the spring scale. By reading the spring scale determine the gram force used.
   b. Place data on chalkboard, with the formula W = Force × Distance and complete the calculation.
      NOTE: Indicate that the unit of work in the metric system is the ***gram centimeter.***
   c. Repeat this procedure, but this time pull the object across the lab table. Illustrate calculation.
3. Distribute materials and encourage pupils to solve the problems.

Materials

Spring scale — 0-2,000 grams
Meterstick
Object of unknown weight
String

Enrichment

Have the class complete the Worksheet calculations, using the English system.

In the lab report, have them indicate which of the two systems they prefer and their reasons.

LABORATORY WORKSHEET — PHYSICS: LESSON 9

Problem: How can we measure work?

Materials

Spring scale — calibrated in grams	String
Meterstick	Sandpaper — 6" x 10"
Hall's carriage	

Procedure and Observations

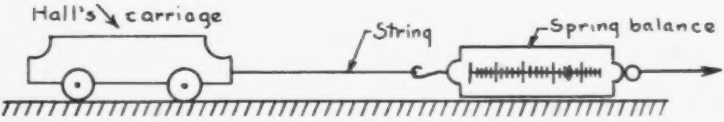
1. Complete the following table based on the data from the teacher's demonstration.

a. Force used (lifting) _____________grams.
Distance moved___________________centimeters.
Work = Force × Distance = _____gms × _____ cm = _____ gm cm

b. Force used (pulling) _____________grams.
Distance moved___________________centimeters.
Work = Force × Distance = _____gms × _____ cm = _____ gm cm

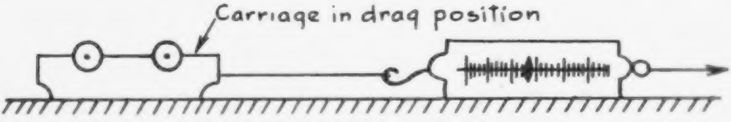
2a. Lift the Hall's carriage 20 cm in the air.
Calculate the work done.
Distance moved = 20 cm
Force used = _____gms (from scale reading)
Work = Force × Distance = _____gms × _____ cm = _____gm cm

b. Roll the carriage 20 cm (pull, using scale)



Calculate the work done.
Distance moved = _____cm
Force used = _____gms (from scale reading)
Work = Force × Distance = _____gms × _____ cm = _____gm cm

c. Drag carriage (upside down) 20 cm (pull, using scale)



Calculate the work done.
Distance moved = _____cm
Force used = _____gms (from scale reading)
Work = Force × Distance = _____gms × _____ cm = _____gm cm

d. Drag carriage 20 cm over sandpaper.
Calculate the work done.
Distance moved = _____cm
Force used = _____gms (from scale reading)
Work = Force × Distance = _____gms × _____ cm = _____gm cm

Conclusions

1. The unit of work in the Metric system is the_______________.
2. Two quantities necessary to find the work done are_______________ and_______________.

Summary

1. Based upon the results of your experiment, which of the methods used to move the carriage used the least amount of work? _______________
2. Would you pull a sled on ice or sand? Explain. _______________
3. Why can you push a car with the brakes off, but not on? Explain. _______________

Homework

1. Write a laboratory report based on the lesson.
2. Why is less work used in rolling a cart than in dragging one?

10.* HOW CAN WORK BE DONE USING LESS FORCE?

LABORATORY LESSON

Outcomes

- Less force is used in pulling an object over a smooth surface than over a rough one.
- On a rough surface, work is wasted overcoming friction.
- Friction can be useful at times.

Motivation

Is it easier to ice skate on ice or on the plain sidewalk?

Development

1. Distribute materials and pupil worksheets.
2. After class has completed lab exercise, introduce the concept of lubricants by having a pupil rub his hands while pressing the palms together. Have him repeat this using soap. Discuss other lubricants.
3. Elicit from the class the use of the wheel and the role it plays in reducing friction.
4. Ask, "Is friction always bad for us?" Tell this story. "Lenny was driving his car on an ice-covered street. When he came to a corner, the light turned red and he stopped the car. When the light changed, he tried to start again, but the back wheels would only spin on the ice. He thought for a moment, got out of his car and let some air out of his rear tires. When he got back into the car, he was able to start without any trouble."

   Ask, "Why was this possible?" Discuss ways in which friction helps us (i.e., in walking).

Materials

Liquid soap

---

* Only for classes programmed for five periods

LABORATORY WORKSHEET — PHYSICS: LESSON 10

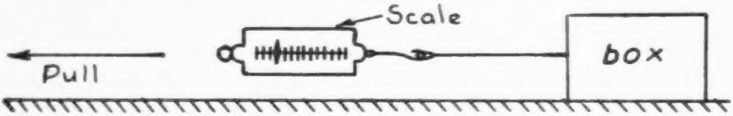
Problem: How can work be done, using less force?

Materials

Spring scale (metric units)	Sandpaper
String	Meterstick
Weighted box or other heavy object	

Procedure and Observation

1. Tie a string to the weighted box and attach this to the scale.



2. Using the meterstick to measure the distance, pull the scale steadily across a smooth desk top for a distance of 50 centimeters.

   NOTE: a. The scale should not touch the desk.
   b. Be careful not to jerk the scale.

3. Record your observations.

   Force____________________grams Distance____________________cm
   Work = Force × Distance = _____ × _____ = _____gm cm

4. Repeat this procedure but this time pull the weighted box over 50 cm of a sandpapered surface.

5. Record your observations.

   Force____________________grams Distance____________________cm
   Work = Force × Distance = _____ × _____ = _____gm cm

Summary

1. On which surface was more force required to pull the weighted box?

   ____

2. On which surface was more work done to move an object the same distance?

   ____

3. Write the formula for work____________________

4. How can you explain the difference in the amount of work done?

____

____

Applications

1. Why are most modern refrigerators mounted on wheels?
2. Why are bowling alleys highly waxed and polished?

Homework

1. What happens to the energy used to overcome friction?
2. Why is soap used to get a tight ring off a finger?
3. Name three things that work better when they are lubricated.
4. What are two ways in which friction helps us?
5. Write up this lab lesson.

11. WHY DO OBJECTS TIP OVER?

Outcomes

- The center of gravity is that point in an object where all of its weight appears to be concentrated.
- The center of gravity is that point about which an object most easily turns.
- An object tips over when its center of gravity is beyond its base.

Motivation

Demonstrate the leaning tower model without its top. Replace the top. Ask, "Why did the tower fall?"

Development

1. Ask a student to come to the front of the room. Have him close his eyes and extend his arm. Place either a ruler, window pole, or meterstick between the thumb and middle finger of his outstretched

hand. Stick should be held at its center of gravity. Ask the pupil, "Are you holding a long or a short object?"

Because all of the weight of an object appears to be concentrated at its center of gravity, it will be difficult for the pupil to determine the answer.

2. Have the pupil grasp the object nearer to its end and ask him to report on its length.
3. Define for the class that the original point, where all the weight appears concentrated, is known as the *center of gravity*.
4. Ask another student to grasp a yardstick one foot from its center of gravity. Have him attempt to rotate it. Ask him to repeat this at its center of gravity. Ask him to report the instance in which the stick rotated most easily.
5. Elicit from class the definition of center of gravity as, "That point in an object about which it turns most easily".
6. Have a pupil stand flush against the wall. Place an object on the floor, two feet in front of him. Ask him to pick it up without bending his knees.
7. Explain to the class with the aid of a diagram that so long as the pupil's center of gravity is directly over his feet (base) he is able to maintain his balance. Once it extends beyond his feet (base) he will tip over.

7a. Introduce the concept of equilibrium (objects that are balanced are in equilibrium). Demonstrate the three types of equilibrium, as follows:

- Stable: *when an object is given a small displacement, the center of gravity will return to its original position. Example: a book lying flat on a table.*
- Unstable: *when an object is given a slight displacement, its center of gravity assumes a lower position. Example: a book balanced on its edge.*
- Neutral: *when an object is given a slight displacement, its center of gravity is neither raised nor lowered. Example: rolling ball or cylinder.*

8. Have the pupils use this principle to explain the leaning tower model falling over.

Summary

1. Give two definitions of center of gravity.
2. Why do tall buildings have a wide base?

Homework

1. Explain why a truck, with a heavy load, may sometimes tip over when rounding a curve at high speeds.
2. Pick out several objects in your home and tell how they are made so that they do not tip over easily.
3. How should we stand in fast moving trains and buses so that we do not fall over? Explain.
4. *Give two examples of stable, unstable, and neutral equilibrium.*

Materials

Leaning tower model
Window pole
Ruler
Meterstick

12. HOW CAN WE FIND THE CENTER OF GRAVITY OF AN OBJECT?

LABORATORY LESSON

Outcomes

- Irregularly-shaped objects have a center of gravity.
- The center of gravity of an object can be determined by experimental means.

Motivation

Show the class various objects such as a hammer, a baseball bat, and the window pole. Have the pupils predict the location of the center of gravity for each object. Some pupil volunteers can test their predictions (in terms of finding the balance point).

Display an irregular-shaped object and challenge the pupils to determine the center of gravity.

Development

1. Distribute materials and Worksheets.
2. Inspect and approve cardboard shapes to be cut out by the pupils (see Worksheet items 1 and 2).
3. Demonstrate, if necessary, method for drawing lines.

Summary

1. After the pupils have completed the activity, summarize by having the pupils restate the two definitions of center of gravity.
2. Guide the pupils in testing their findings by balancing the figure at points other than the center of gravity point.

Materials

Hammer
Baseball bat
Window pole
Irregularly shaped object

Enrichment

Encourage pupils to investigate finding the center of gravity of any triangular object. To find the center of gravity here, draw lines from each corner of the triangle to the midpoint of the opposite side. The intersection of the lines is the center of gravity. Have the pupils verify this experimentally with various types of triangles.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 12

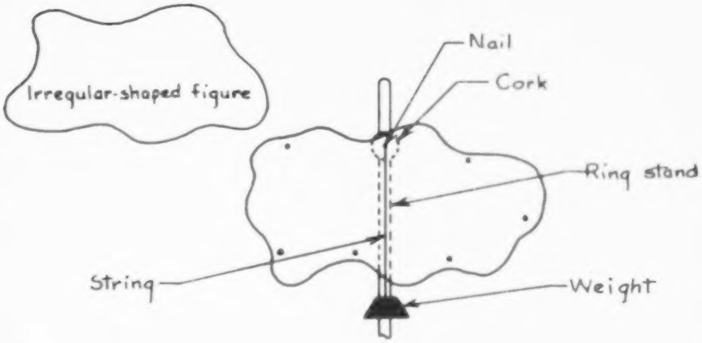
Problem: How can we determine the center of gravity of an object?

Materials

Cardboard 12" x 12"
Scissors
Pencil
Ruler
String
Cork
50 gram weight
Nail
Ring stand, clamp

Procedure and Observation

1. Draw an irregular-shaped figure on the cardboard. Have your teacher approve this before cutting it out.
2. Cut the figure from the cardboard and make seven holes at different points approximately ¼" from the edge.
3. Place the nail into the cork and clamp this combination to the ring stand. Hang the figure from it by one of its holes. The following diagram may be helpful.



4. Tie one end of the string to the 50-gram weight.
5. Tie the other end to the nail, so that the weighted string hangs down in front of the cardboard.
6. Using ruler and pencil, mark on the figure, the line made by the string.
7. Hang the figure from each of its other holes in turn, repeating steps 5 and 6 each time.
8. After all lines have been drawn, try to balance the figure on your finger at the point where all the lines meet.
9. Based on your previous learnings, test the figure to determine if you have actually found its center of gravity. How would you test your figure to prove you did find the center of gravity point?

Conclusions

1. Using your own words, describe how you can find the center of gravity of an irregularly shaped figure. ______________________________

____

Summary

1. Where is the center of gravity of a wheel located? ______________________

____

2. How can we improve the experiment we just performed? ______________

____

Homework

1. Write up a lab report based on the lesson.
2. The balance point of an object is also known as the ____________

______________________________.

MACHINES

Suggested Lessons and Procedures

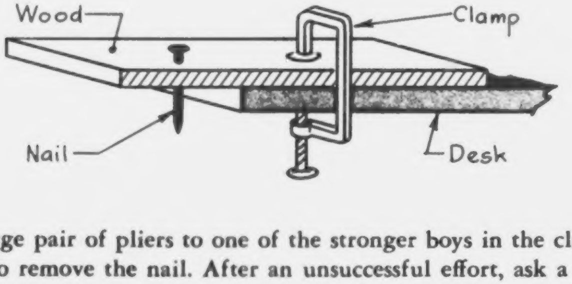
13. HOW CAN WE USE A SMALL FORCE TO MOVE A HEAVY OBJECT?

Outcomes

- A lever multiplies the force used to move an object.
- Mechanical advantage is the number of times a force is multiplied.

Motivation

Prepare, in advance, a 2″ x 4″ x 6″ block of wood with a large nail driven to within ¼″ of the surface. Clamp the wood to the table as shown:

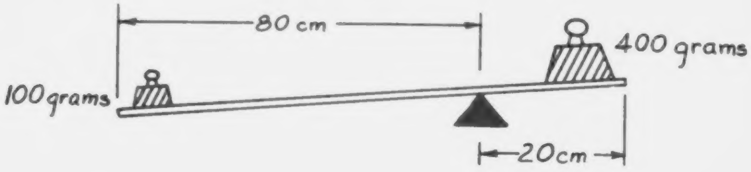


Give a large pair of pliers to one of the stronger boys in the class and ask him to remove the nail. After an unsuccessful effort, ask a girl to do this but issue her a claw hammer. Discuss with the class the ease with which the girl removed the nail. Ask how the hammer helped the girl remove the nail. Elicit the term *leverage* or that a *lever* made the job easier.

Another demonstration would be to have two pupils of unequal weight stand on a 2′ x 4′ board, raised at the fulcrum. Ask pupils to explain why a lightweight pupil standing further from the center (*fulcrum*) can balance a heavier pupil standing closer to the fulcrum.

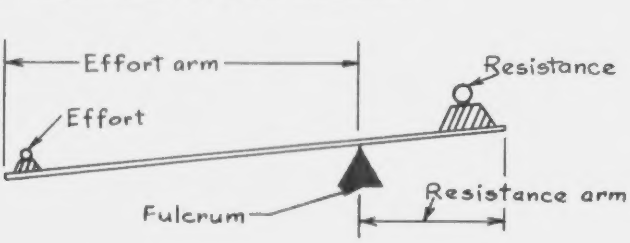
Development

1. Set up the following demonstration:



Challenge the class by stating: "We know that a 400 gram weight could lift a 100 gram weight; but how could a 100 gram weight lift a 400 gram weight?" Have the pupils suggest ways of using the lever to accomplish this.

2. Diagram the solution of the problem on the chalkboard and define the following:
   a. fulcrum — the point about which a lever rotates
   b. effort or force — applied force
   c. effort arm — distance from effort or force to fulcrum
   d. resistance — amount of force that can be overcome by the applied force
   e. resistance arm — distance from fulcrum to weight or resistance.
3. Label diagram using the above definitions.



4. Develop the generalization that a lever can multiply a force. By asking how many times this force can be multiplied, introduce the concept of ***mechanical advantage*** as the number of times that a lever multiplies a force.

5. Refer to the labelled diagram. Using this, develop the understanding that the only two factors that affected the ***mechanical advantage*** of the lever were the effort arm (the distance between the effort and fulcrum) and the resistance arm (the distance between fulcrum and resistance). Have pupils conclude that a lighter weight further from the fulcrum can lift a heavier weight closer to the fulcrum.

Summary

1. What is a fulcrum?
2. Where is the fulcrum in a seesaw?
3. Compare the bottle opener to a lever.

Homework

1. List 3 devices used at home which work on the principle of the lever.
2. Why is it easier to use a wrench with a long handle, than a short one?

Materials

Wood block 2" x 4" x 6"
Hammer
Long nail
Pliers

Meterstick
100, 400 gram weights
Dowel used as fulcrum
"C" clamp

Enrichment

Refer to development step 1. Challenge the class to explain why the lever does not violate the principle of Conservation of Energy. Have the class calculate the amount of work done on both ends of the fulcrum.

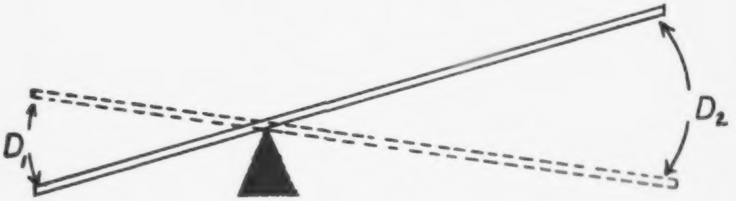
NOTE: *"D" from formula $W = FD$ is the distance (height) through which the weights move.*

Example: 100 gm side $W = F \times D$

$W = 100 \text{ gms} \times 4 \text{ cm} = 400 \text{ gm cm}$

400 gm side $W = F \times D$

$W = 400 \text{ gms} \times 1 \text{ cm} = 400 \text{ gm cm}$



14. HOW CAN WE DETERMINE THE MECHANICAL ADVANTAGE OF A LEVER?

Outcome

- The mechanical advantage of a lever may be calculated in two ways:
  1. effort arm divided by the resistance arm
  2. resistance divided by effort

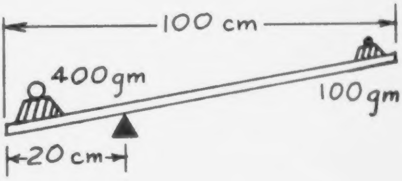
Motivation

Have the class recall the circus act in which a girl jumps from a high platform onto a seesaw and propels a heavy man into the air. Elicit this as an application of the lever and ask, "How can we find the force applied by a lever?"

Development

1. To answer the question, set up a lever as shown:

   Label and dimension the effort, resistance, effort arm, and resistance arm.



1a. Using specific examples, establish that levers can be grouped into three classes. The classes differ depending upon the relative positions of the fulcrum, effort and resistance. Elicit examples of each class and guide pupils in identifying the positions of the fulcrum, effort arm, and resistance arm.

2. Ask, "How much weight could the 100 gm lift?" Elicit that the mechanical advantage of this lever is 4 because it has multiplied the force 4 times.

3. Show the following methods of finding the MA:

   a. $\frac{\text{Effort arm}}{\text{Resistance arm}} = \frac{80 \text{ cm}}{20 \text{ cm}} = 4$

   b. $\frac{\text{Resistance}}{\text{Effort}} = \frac{400 \text{ gm}}{100 \text{ gm}} = 4$

3a. Using a sample calculation, establish that the mechanical advantage of a lever is independent of the system of measurement.

4. Organize a Worksheet with problems such as those suggested below. It may be helpful to have a diagram accompany each problem. Have the pupils find the mechanical advantage.

   a. effort arm = 100 cm
      resistance arm = 20 cm

   b. effort = 100 gms
      resistance = 20 gms

   c. effort arm = 10 ft.
      resistance arm = 2 ft.

   d. effort = 100 lbs.
      resistance = 20 lbs.

   e. effort arm = 12 ft.
      resistance arm = 4 ft.

5. Identify, preferably with diagrams, the following as applications of levers. Challenge the class to find the various parts of a lever:

   fishing rod
   nutcracker
   crowbar
   wheelbarrow
   scissors
   pliers

5a. Elicit that in addition to multiplying the force, a lever also changes its direction.

Summary

1. List two ways of finding the mechanical advantage of a lever.
2. Give the definition of resistance arm.
3. How does a lever give us a mechanical advantage?

Homework

1. The effort arm of a lever is 10 ft. long, the resistance arm is 2 ft. How much does it multiply the force?
2. Draw a pair of pliers. Label the fulcrum.
3. Scissors used for cutting paper have short handles and long blades. Those used to cut metal have long handles and short blades. Why?
4. *Given a stick 10 feet long, where should the fulcrum be placed to obtain a mechanical advantage of 4?*

Materials

Meterstick
100 and 400 gram weights
Dowel (use as fulcrum)

15. *HOW CAN WE INCREASE THE MECHANICAL ADVANTAGE OF A LEVER?

LABORATORY LESSON

Outcomes

- The mechanical advantage of a lever may be increased by moving the fulcrum.
- The mechanical advantage is independent of the effort and resistance.

Motivation

Exhibit several different, simple machines. Ask "What is a machine?" Guide the class to the response that a machine is a device which makes work easier by multiplying the force.

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* Only for classes programmed for five periods

Development

1. Distribute Worksheet and materials to class.
2. Demonstrate one of the experiments with the class to show how the materials are used.
3. Challenge the pupils to solve the problem on their Worksheets.

Summary

When pupils have completed the investigations, summarize by asking:

1. What happens to the mechanical advantage of a lever as the effort arm becomes longer and the resistance arm shorter?
2. Explain the statement "If I had a long enough stick and a place to stand I could move the earth."

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 15

Problem: How can we increase the mechanical advantage of a lever?

Materials

Meterstick	Set of gram weights
String	Ring stand and clamp

Procedure and Observations

1. Define the following (you may refer to your notes).

   a. effort ______________________ c. resistance ______________________
   b. effort arm ______________________ d. resistance arm ______________________

2. Tie a string around the 50 cm mark of the meterstick, and suspend this from the ring stand. (Attach clamp to ring stand approximately 15 cm from base.)
3. At the 1 cm mark of the meterstick attach a 100 gm weight.
4. By carefully adding weights at the 99 cm point, find out the smallest number of grams needed to lift the 100 gm resistance.
   Record this number ______________________ gms.
5. Calculate the mechanical advantage of the lever:

$$\text{Mechanical advantage} = \frac{\text{resistance}}{\text{effort}} = \frac{\underline{\qquad\qquad}\ \text{gms}}{\underline{\qquad\qquad}\ \text{gms}} =$$

6. Move the fulcrum to the 75 cm mark.

7. Place a 300 gm weight at the 99 cm mark. Find the least amount of effort needed to overcome this resistance. Record this number____________gms.

8. Calculate the mechanical advantage of the lever:

$$\text{Mechanical advantage} = \frac{\text{resistance}}{\text{effort}} = \frac{\qquad\qquad\text{gms}}{\qquad\qquad\text{gms}} =$$

9. Move the fulcrum to the 90 cm mark. Place a 1,000 gm weight at the 99 cm mark. Find the least amount of effort needed to overcome this resistance. Record this number____________________gms.

10. Calculate the mechanical advantage of the lever:

$$\text{Mechanical advantage} = \frac{\text{resistance}}{\text{effort}} = \frac{\qquad\qquad\text{gms}}{\qquad\qquad\text{gms}} =$$

11. Summarize your findings about levers in this table of information:

EFFORT ARM	RESISTANCE ARM	EFFORT	RESISTANCE	MECHANICAL ADVANTAGE
1.				
2.				
3.				

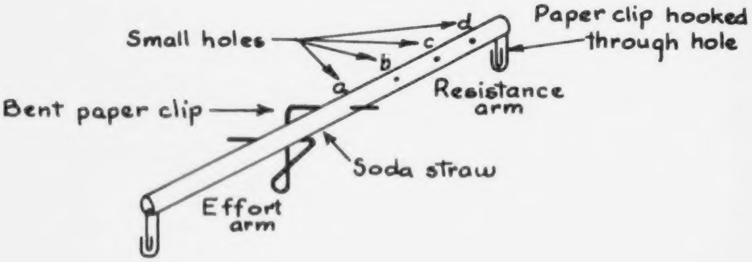
Summary

1. How can you change the mechanical advantage of a lever?

2. How can you increase the mechanical advantage of a lever?

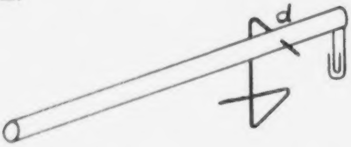
Homework

1. Construct a simple straw lever:



2. **By using different combinations of paper clips on the effort arm and resistance arm, investigate the mechanical advantage of this lever at points A, B, C, and D. (different fulcrum points)**

   Note: As you experiment with the lever you will find that at point "D" the lever can move a paper clip on the resistance side with no paper clip on the effort side. Can you explain why this happens?



16. WHY DO OBJECTS TURN?

Outcomes

- Moment of force equals force times moment arm.
- A meterstick will not rotate if the moments on the right side equal the moments on the left side.

Motivation

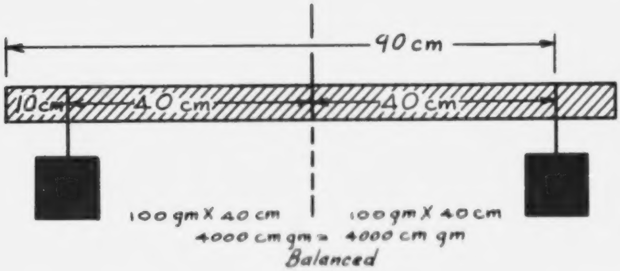
Describe the following situation. Two boys, each the same weight, are on a seesaw, yet they are not balanced. Why?

Development

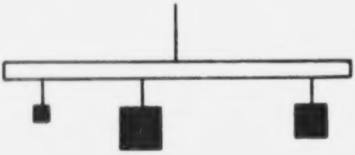
1. Using a meterstick suspended from a ring stand, construct a model (of the above problem) using two 100 gram weights.
2. Establish the importance of the distance of the weight (force) from the fulcrum as well as the magnitude of the force.
3. Introduce by definition the ***moment arm*** as the distance between the force and the fulcrum.

3a. Distinguish between forces tending to turn an object clockwise (positive moments) and those tending to turn an object counterclockwise (negative moments).

4. Challenge a pupil to balance the meterstick using both 100 gram weights. When this has beeen accomplished, place the following labelled diagram on the chalkboard.



4a. *Illustrate how the Law of Moments operates, using three forces.*



5. Explain to the class that force times moment arm is called moment of force. It is measured in centimeter grams.

6. Place the following equation on the chalkboard.

   Moment of Force = Force × Moment Arm
   (Distance from the force to the fulcrum)

7. Have a pupil balance a 100 gm and a 200 gm weight by sliding them along a meterstick. Diagram on the chalkboard as in step #4. Repeat this with 100 gms and 300 gms. Have the pupils make a diagram and calculate the moments.

8. Call attention to the fact that the meterstick is balanced when the moments on the right side equal the moments on the left side.

8a. *When the sum of the clockwise moments equal the sum of the counterclockwise moments, the system is balanced.*

Summary

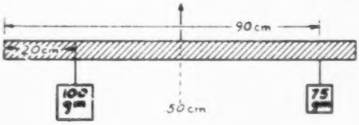
1. How can a thin boy balance a heavy boy on a seesaw?

2. **Define moment of force.**

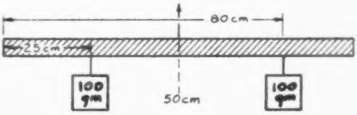
3. **When is a seesaw balanced?**

Homework

1. **Find the moment of force on both sides of this meterstick. Will it balance? Why?**

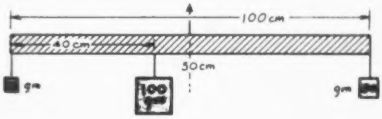

90 cm
20 cm
100 gm
50 cm
75 gm

2. **Find the moment of force on both sides of this meterstick. Will it balance? Why?**


80 cm
25 cm
100 gm
50 cm
100 gm

3. ***What is a moment arm similar to in a lever system?***

4. ***Will the stick balance? Why?***


100 cm
40 cm
50 cm
gm
100 gm
gm

Materials

Ring stand, clamp	String
Meterstick	Set of gram weights

17. *HOW CAN WE PREDICT WHETHER A METERSTICK WILL BALANCE?

LABORATORY LESSON

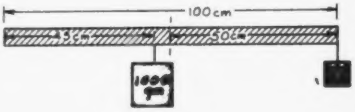
Outcomes

- **Weights placed far from the fulcrum tend to turn an object more than weights placed near the fulcrum.**
- **When the moments on both sides of a meterstick are equal, the stick will balance.**

*** Only for classes programmed for five periods**

Motivation

Set up the following moment of force demonstration. Support it with your hands and ask the class, "When I take my hands away, will it balance?"



Development

1. Distribute Worksheet and materials to class.
2. Read instructions with class to insure understanding of the laboratory exercise.
3. Encourage students to solve the Worksheet problems.

Materials

Meterstick	String
Ring stand, clamp	Set of gram weights

(May be duplicated for use by pupils)

LABORATORY WORKSHEET — PHYSICS: LESSON 17

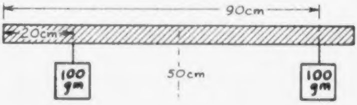
Problem: How can we predict whether a meterstick will balance?

Materials

Meterstick	Set of gram weights
Ring stand-clamp	String

Procedure and Observation

1. Using the diagram, suspend the meterstick from the 50 cm mark.



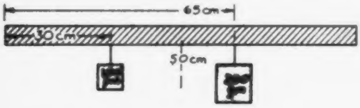
2. Attach a 100 gram weight at the 20 cm mark and another 100 gram weight at the 90 cm mark. The above system (is, is not) balanced____________.
3. Find the moment of force on the left side of the meterstick.

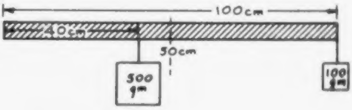
   MF = F × Moment Arm =_______×_______=_______cm gram.

4. Find the moment of force on the right side of the meterstick.
   MF = F × Moment Arm =_______×________=____.___cm gram.

5. Since the moments on the right-hand side (do, do not)______________equal the moments on the left-hand side, the stick (is, is not)______________ balanced.

6. By finding the moments on the right-hand side and on the left-hand side, predict whether the following system will balance:



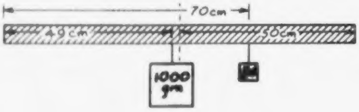


   It (will, will not)____________________balance.

7. Test your answers by setting up the actual metersticks and weights.

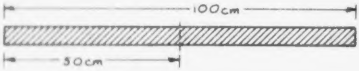
   NOTE: Place the string exactly on the mark indicated or your results will not be accurate.

8. Set up a balanced meterstick:



   Why can the small weight balance the large one?

9. Using the diagram, find a different position at which the weights will balance.



   Fill in their positions on the diagram and find the moment of force on both sides.

Summary

1. a. What happens to a balanced meterstick if one of the weights is moved away from the fulcrum? ________________________
   b. What happens if a weight is moved toward the fulcrum?
   ____

2. Where should a large weight be suspended so as to have the smallest effect on the meterstick?________________________

3. A 100 gram weight is suspended 50 cm from the fulcrum of a meterstick, where should another 100 gram weight be placed to balance the stick? Explain. ________________________

Homework

1. To what machine is a balanced meterstick similar?
2. Name two ways in which to increase the moment of force.
3. Write a lab report based upon today's lesson.

18. WHY ARE RAMPS USED TO LOAD SHIPS AND TRUCKS?

Outcomes

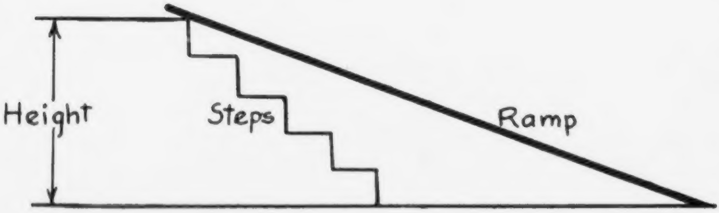
- The ramp is an example of the simple machine called the inclined plane.
- The inclined plane decreases the force needed to lift an object.
- The actual mechanical advantage of an inclined plane $= \frac{\text{resistance}}{\text{effort}}$
- The steeper, the inclined plane, the smaller is its mechanical advantage.

Motivation

Present the following to the class: Suppose you wanted to lift a heavy piano into a moving van. All you have to help you is several long boards. What would you do?

Development

1. Discuss with the class the advantage of rolling a piano up a ramp or lifting it up a flight of stairs. The following diagram may be helpful:



2. Establish that in both cases the piano is lifted to the same height.

3. Suggest to the class that it would not be practical to experiment in the classroom with a piano so a smaller object may be used. (Hall's carriage is a good substitute).

4. Attach a spring scale to the carriage and lift it straight up as you would if you were carrying it. Record the force required.

5. Set up a ramp (***inclined plane***) and, using the spring scale, pull the carriage up the plane. (The height in both instances (4 and 5) should be the same). Record the force used.

6. Establish that the inclined plane has multiplied the force. The inclined plane is thus a simple machine.

7. Ask, "How much did the ramp multiply the force?" Have the pupils recall that this is simply another way of asking what is the mechanical advantage. Find, with the class, the actual mechanical advantage of the plane using the equation $MA = \frac{\text{resistance}}{\text{effort}}$.

7a. Discuss the formula $MA = \frac{distance}{height}$ *for finding the ideal MA of an inclined plane. Set up an inclined plane and have class calculate its ideal and actual MA. Challenge the class to account for the discrepancy. Repeat this, using a different slope.*

8. Referring to the original ramp, challenge the class with, "What will happen to the mechanical advantage if we make the ramp steeper?" By experiment, establish that as the height of the ramp becomes greater, its mechanical advantage becomes smaller.

8a. Using specific examples (see homework #5), develop work done using a ramp, and work done in lifting the weight to a certain height. Elicit relationship.

9. Have the pupils conclude that although less effort is needed with a ramp, the push is exerted over a greater distance than if the object were lifted.

Summary

1. What is another name for a ramp?

2. Why is the inclined plane called a simple machine?
3. Why is it easier to push a piano up a gentle slope than a steep one?

Homework

1. The mechanical advantage of an inclined plane = __________.
2. Give three examples of inclined planes.
3. A 30 pound push can move a 90 pound object up a ramp. Find the mechanical advantage.
4. *Why do trucks slow down less when climbing a hill on modern highways?*
5. *A 6 lb. force is used to push a 10 lb. object a distance of 10 feet on an inclined plane. The object is lifted to a height of 5 ft.*
   - *What is the mechanical advantage?*
   - *How much work is done?*
   - *How much work would be done if the object were lifted 5 feet without using the plane?*
   - *What is the relationship between the amount of work done on the inclined plane and the amount of work done lifting? Why?*

Materials

Hall's carriage
String
Inclined plane
Spring balance

19. HOW DO PULLEYS HELP LIFT HEAVY WEIGHTS WITH LESS EFFORT?

LABORATORY LESSON

Outcomes

- A pulley can be used to multiply force.
- When a pulley system increases the force exerted on an object it decreases the distance the object moves.

Motivation

A workman named Stanley had to deliver a refrigerator, packed in a crate, to the second floor of an apartment house. The crate with the refrigerator weighed 200 pounds. Stanley tried to lift the crate, but was able to exert a force of only 100 pounds. He remembered that his boss had given him a pulley and a rope but he forgot how to use them. Can you help Stanley solve the problem, using the rope and pulley, so that he won't get fired?

Development

1. Before the laboratory lesson begins, display models of the single movable and single fixed-single movable *pulleys.*
2. Distribute the Worksheets and materials.
3. Encourage the class to solve the problems on their Worksheets. Although it is most desirable that the pupils work independently, it may be necessary to assist some pupils in setting up the more complicated pulleys.

Enrichment

Remember that Work = Force × Distance.

1. How much work did you do in lifting the 200 gram weight in each pulley system? How much work was done on the weight?

TYPE OF PULLEY	WORK YOU DID	WORK DONE ON WEIGHT

2. Can you really get more out of a pulley system than you put in?

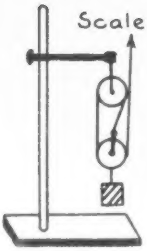
(MAY BE DUPLICATED FOR USE BY PUPILS)

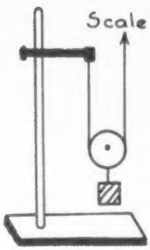
LABORATORY WORKSHEET — PHYSICS: LESSON 19

Problem: How can we lift heavy weights with little effort?

Materials

Ring stand with clamp
Two single pulleys
Two metersticks
String
Spring scale (0-250 grams)
200 gram weight





Procedure and Observations

1. Set up the single movable pulley with a 200 gram weight (see diagram above).
   a. How much force is needed to lift the 200 gram weight?

      Force = ________________grams

   b. How high does the weight move when you move the spring scale 20 centimeters? Distance = ________________centimeters

2. Set up the single fixed-single movable pulley system. Hook a 200 gram weight to the bottom pulley.
   a. How much force is needed to lift the 200 gram weight?

      Force = ________________grams

   b. How far does the weight move when you move the spring scale 20 centimeters? Distance = ________________centimeters

3. Enter your observations on the table.

TABLE OF OBSERVATIONS

TYPE OF PULLEY	WEIGHT LIFTED	FORCE USED	DISTANCE SCALE MOVED	DISTANCE WEIGHT MOVED

Summary

1. Use the data from the table of observations to answer the following questions:
   a. What happened to the forces needed to lift the 200 gram weight as you used different types of pulleys?

      ____

      ____

b. What happened to the distance the 200 gram weight moved as you used different types of pulleys?

c. Do pulleys give "something for nothing"? Explain.

d. What do you give up to increase the force in a pulley system?

Homework

1. List several ways that you could use a pulley system to help you build a house.
2. Complete summary questions.
3. Write up a lab report based on the lesson.

DENSITY AND PRESSURE

Suggested Lessons and Procedures

20. WHY DO OBJECTS FALL?

Outcomes

- All objects fall toward the center of the Earth.
- The weight of an object is determined by the force of gravity.
- The force of gravity is proportional to the mass of an object.

Motivation

Demonstrate the double-cone inclined plane paradox. (S-1 #14-0268). Challenge the class by asking, "Explain how this can happen." Elicit that this appears to defy the *law of gravity* by rolling uphill.

Development

1. Tell the story of Newton and the apple tree. End with this question: "Why did Newton think that this falling apple was so unusual; after all, people had seen apples falling for thousands of years?"
2. Draw a circle on the chalkboard representing the earth. At the top, indicate a man sitting under an apple tree.
3. Challenge the class to suggest what might happen to a man under an apple tree on the opposite side of the circle (Earth).

4. Elicit from the class that from the standpoint of the first man, the second apple is falling up.

5. Repeat this for several other points on the circle and ask, "Toward what point are the apples falling?" If class has difficulty in responding, lines may be extended to indicate point of intersection.

6. Lead the class to the generalization that all objects fall toward the center of the earth.

6a. *Refer to the lesson on center of gravity. Develop the understanding that for 3-dimensional objects the center of gravity lies within the object. Objects fall towards the earth's center of gravity.*

7. Refer to motivation and indicate that by close examination, the double cone is in fact lowering its center of gravity. Have pupils attest to this.

8. Have a pupil come to the front of the room. Ask him to broad jump. Indicate to the class that on the moon he would be able to jump about 30 feet. Ask them why.

9. Elicit the fact that we would weigh less on the moon. Tell the class that objects on the moon weigh $\frac{1}{6}$ of their earth weight. Calculate the weight of several objects on the earth and the moon.

9a. *Explain that as you increase the mass of a body, you increase its force of gravity, and that as you go further away from its center, the force becomes smaller. Newton stated, "The force of gravity is directly proportional to the product of the masses and inversely proportional to the square of the distance between them." This may be written:*

$$F = \frac{GM_1M_2}{r^2}$$

By drawing two circles on the chalkboard, indicate that "r" is the distance between their centers of gravity.

10. Ask if anything about the object is changed by weighing it on the moon. Develop the difference between *mass* and *weight* by leading the pupils to the understanding that only the weight is changed and that the mass remains the same.

11. Explain to the class that bodies with large masses such as the Earth have large forces of *gravity*. Objects with smaller masses

such as the moon have proportionally smaller forces. Therefore you weigh more on the earth than you do on the moon.

Summary

1. If objects could fall through the Earth, where would they all meet?
2. Why do objects weigh less on the moon?
3. Why would an object weigh more on the sun than it does on the Earth?

Homework

1. How much would an object weighing 10 pounds on the moon weigh on the Earth?
2. An object at the north pole falls down. An object at the south pole also falls down. Explain.
3. Are mass and weight always the same? Explain.
4. *Complete the table:*

FORCE OF GRAVITY EARTH	BODY	OBJECT WEIGHT
	Mercury	8.25 lbs.
	Venus	
1	Earth	150 lbs.
0.1	Mars	
	Sun	
	Moon	25 lbs.

NOTE: *Consult an encyclopedia or science textbook for additional information.*

Materials

Double cone-inclined plane

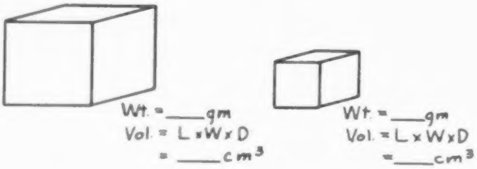
21. HOW CAN THE WEIGHT OF DIFFERENT MATERIALS BE COMPARED?

Outcomes

- The ratio of weight to volume is called density. Density equals weight divided by volume.
- Different materials usually have different densities.

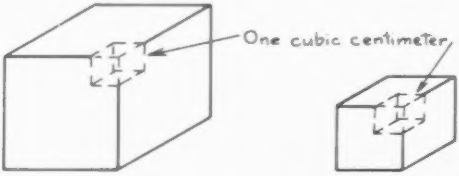
Motivation

Display the large and the small blocks of wood. Ask the class which is heavier. Class should suggest that blocks be weighed. After determining the weights, challenge class by asking, "Is this block heavier because it is larger, or because it is made of a heavier material?"



Development

1. After a short discussion, the need for knowing the volume of the wood blocks should arise.
2. Calculate these with the class and place the information on the chalkboard.
3. Pose the question again, "Is this block heavier because it is larger, or because it is made of a heavier material?" Now the need for having the blocks the same size should be developed. A diagram may be helpful:



The class should be led to the conclusion that if a 1 cubic centimeter cube from each block could be obtained, it would then be a simple matter to determine which material was the heavier.

4. Rephrase the above problem to, "How much does each cubic centimeter of each block weigh?" Show that this can be found by dividing the weight in grams by the volume in cubic centimeters.

4a. Show that density is different in the English system (*lb/ft*^{3}).

Find the density of the following materials:
100 cubic feet of water weighs 6250 lbs.
10 cubic feet of lead weighs 7050 lbs.
500 cubic feet of oak weighs 750 lbs.
10 cubic feet of mercury weighs 8492 lbs.

5. Define this new number as the *density*. $\text{Density} = \frac{\text{Weight}}{\text{Volume}}$
6. Find the densities of the two wooden blocks to determine which material is more dense.

Summary

1. How can the density of a material be found?
2. How can we compare the weights of different materials?
3. If these two blocks were the same size which would be heavier? Why?

Materials

Triple beam balance	Large block of dense wood (oak, maple)
Meterstick	Small block of less dense wood (balsa, pine)

Homework

1. Which weighs more, a pound of feathers or a pound of lead?
2. Which is more dense, a pound of feathers or a pound of lead?
3. *Find the densities of the materials on the chart, using the formula:*

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}}$$

MATERIAL	VOLUME	WEIGHT	DENSITY
Alcohol	100 cc	79 gms	
Water	100 cc	100 gms	
Wood (oak)	100 cc	60 gms	
Silver	100 cc	105 gms	
Lead	100 cc	1134 gms	
Mecury	100 cc	1356 gms	

22. HOW CAN THE DENSITY OF A LIQUID BE FOUND?

Outcomes

- Different liquids have different densities.
- Water has a density of 1 gram per cubic centimeter.

Motivation

Prepare two small stoppered test tubes by filling one with mercury and the other with water. Have a pupil come to the front of the room and lift each test tube separately. Ask him to report his observation to the class. Ask, "Why is one test tube heavier than the other?" Establish that one liquid is more dense than the other.

Development

1. Prepare in advance, four 250 ml beakers containing 100 cc each of mercury, water, alcohol, and glycerine. Do not label.
2. Challenge the class by asking, "What tests can be used to help us identify these liquids?"
3. Place the table of densities on the chalkboard. (See page 158.)
4. Explain that every material has its own characteristic density.
5. Place the formula for density on the chalkboard.

6. Elicit from the class that by finding the density of the liquids in the beakers, the liquids can be identified.

   Note: It should be pointed out that a single test is rarely used to determine the identity of a material.

LIQUID	DENSITY IN GM/CM^3
Alcohol	0.8
Water	1.0
Glycerine	1.3
Carbon tetrachloride	1.6
Sulfuric acid	1.8
Mercury	13.6

7. Weigh 100 cc of each of the sample liquids. Be sure to subtract weight of beaker.
8. Introduce equality of cc to ml.
9. Place the data on the chalkboard and have students calculate the density, using the formula.

9a. Have the class suggest other tests that might be used to confirm identification.

Examples: litmus, luster, flammability, color, etc.

10. Using the density table, have the pupils make identifications.

10a. Introduce specific gravity as the weight of a material compared to the weight of an equal volume of water. Show that specific gravity is the same in all systems.

$$\text{Eng.}\begin{cases} \frac{10\ \text{cu. ft. Hg} = 8492\ \text{lbs.}}{10\ \text{cu. ft. } H_2O = 625\ \text{lbs.}} \end{cases} = 13.6$$

$$\text{Met.}\begin{cases} \frac{10\ \text{cc Hg} = 136\ \text{gms}}{10\ \text{cc } H_2O = 10\ \text{gms}} \end{cases} = 13.6$$

11. Indicate to the class that water has a density of 1 and is used as a standard throughout the world.

Summary

1. What two things must be known before the density of a liquid can be found?________________.

2. What is the density of water?____________________.

Homework

1. Distribute the following table to the class.

LIQUID	DENSITY
1. grain alcohol	0.78
2. wood alcohol	0.79
3. carbon tetrachloride	1.59
4. glycerine	1.26
5. kerosene	0.8
6. mercury	13.55
7. sulfuric acid	1.83
8. water	1.0

Using the above information, calculate the density and identify the liquid.

LIQUID	WEIGHT	VOLUME	DENSITY
	10 gr.	10 cc.	
	25 gr.	31.2 cc.	
	15 gr.	8.4 cc.	
	677.5 gr.	50 cc.	

Materials

Balance
Graduated cylinder, 250 ml
Mercury
Water
Test tubes and rack

Stoppers
250 ml beakers (4)
Alcohol
Glycerine

23. *HOW CAN THE DENSITY OF A METAL BE FOUND?

LABORATORY LESSON

Outcomes

- The volume of a rectangular solid is found by multiplying the length × height × depth.
- Pure metals may be identified by their densities.

Motivation

Ask the students to imagine the following situation: You are in a silver mining town. A prospector offers to sell you some silver at a low price. You suspect that it is not really silver. How can you test it?

Development

1. Explain that each pure metal will have its own density which can be used to help identify it. In today's investigation, they will learn how to find the density and compare it to the density table for identification.
2. Distribute Worksheets and materials.

   NOTE: Metal block used for pupil activities should be aluminum density blocks S-1 #14-0528.
3. Read the instructions on Worksheet with the class.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 23

Problem: How can the density of a metal be found?

Materials

Metal block

Metric ruler

Spring scale

Procedure

1. The following table gives the density of various metals:

---

* Only for classes programmed for five periods

METAL	DENSITY GMS/CM^3
iron	7.8
lead	11.3
silver	10.5
gold	19.3
aluminum	2.7
tin	7.3
copper	8.9
mercury	13.6

When you find the density of your metal block, compare it with the table of densities to find out if it is silver.

2. To find the density of any material, you must know its weight and its volume. Find the size of the metal block and then calculate its volume.

Length = ____ cm height = ____ cm depth = ____ cm

Volume = L × H × D = ____ × ____ × ____

= ____ cubic cm

3. Find the weight of the block. (Remember to read the scale at eye level.) Take the average of 3 readings to improve your accuracy.

1.______gms 2.______gms 3.______gms

Average weight = ____________ gms

4. Density = $\frac{\text{Weight (in grams)}}{\text{Volume (in cubic cm)}}$

Find the density of your block. Density = ________ gm/cm^3

5. Compare the density of the block with the table of densities. Is the block silver? How do you know?

6. If the block is not silver, what might it be? ________ Why?

Summary

1. What two things about an object must be known to find its denity.
2. How can the volume of a block be found?
3. What is the density of silver? ________ Of aluminum? ________
4. What is one way to tell the difference between aluminum and silver?

Homework

1. What is one way a jeweler could tell the difference between real gold and gold plated objects?
2. A handful of silver coins have a volume of 10 cubic cm and a weight of 80 grams. Are they pure silver?

24. WHAT IS MEANT BY PRESSURE?

Outcomes

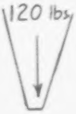
- Gases, liquids, and solids exert pressure.
- Pressure in gases and liquids increase with depth.

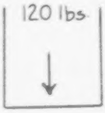
Motivation

Tell the following: "While coming to school on the train several days ago, a lady stepped on my foot. It hurt a great deal. When I looked down, I noticed that she was wearing high-heeled shoes. The very next day, the same lady stepped on my foot again. This time it didn't hurt as much. When I looked down, I noticed that she was wearing flat-heeled shoes. Can you explain why it didn't hurt as much?"

Development

1. Draw the diagram:





2. Elicit that although the force exerted by the woman had not changed, the narrower heel had concentrated this force.

2a. *Develop the formula.* $\text{Pressure} = \dfrac{\text{Force}}{\text{Area}}$

Show by calculation that pressure can be increased in two ways:

a. increase the force *b. decrease the area*

3. Define this as an increase in the amount of pressure.
4. Prepare the following demonstration.
   a. Cut the top off an empty milk container.

b. At a height of 5″ from the base, punch four small holes, one in the middle of each side.

c. Repeat this at 3″ and 1″ from the base.

d. Place container into a large pan and allow a constant flow of water to enter the container.

NOTE: Do not allow water to overflow container.

5. By observing the streams of water, demonstrate to the class the pressure differences at the various levels.

6. Elicit that the pressure is

   a. The same in all directions.

   b. That the pressure is a result of the weight of the water.

   c. The pressure increases with depth.

7. To demonstrate air pressure, set up the following:

   a. Fill a large tin can with approximately 1 inch of water.

   b. Place on tripod and heat to boiling.

   c. After steam has been visible for 1 minute, screw on cap and remove from flame.

7a. Develop a more sophisticated approach to air pressure. Explain that air pressure is due to the bombardment and collision of air molecules with an object. As you go higher into the atmosphere, the number of molecules decrease, resulting in a decrease in air pressure. This also explains why air pressure is uniform in all directions.

8. Develop the following understandings:

   a. Originally the can contained water and air.

   b. The steam produced pushed the air from the can.

   c. When the can was cooled, water condensed leaving a partial vacuum.

   d. The can collapsed because of the greater air pressure on the outside surface of the can.

Summary

1. Does the same force always exert the same pressure? Explain.

2. In a swimming pool, where is the pressure greatest? Why?
3. What causes our ears to "pop" when we go to the top of the Empire State Building, or go up in a fast elevator?

Homework

1. A milk container filled with water has holes punched in the top, middle and bottom. From which hole will the water be forced out the farthest? Why?
2. What happens when you remove the air from a tin can? Why?
3. *Although women are lighter than men, why do women wearing high heels make marks on wooden floors?*

Materials

Tin can with screw cap
Empty milk carton
Rubber tubing
Shallow pan
Tripod
Wire gauze
Bunsen burner
Scissors

25. HOW CAN THE PRESSURE IN A LIQUID BE MEASURED?

LABORATORY LESSON

Outcomes

- Water pressure is measured with a manometer.
- Water pressure is equal in all directions at any given depth.

Motivation

Ask the class if there are any divers in the room. What effect does diving have on their eardrums? Elicit that the water pressure makes their eardrums hurt. In the laboratory activity, class will learn how to construct a simple instrument to measure pressure in water.

Development

1. Demonstrate the operation of the manometer. If none is available, construct one following the instructions on the students' lab sheet.

2. Distribute the pupil worksheets and material to groups of pupils. Illustrate the proper method of attaching the "U" tube to the cardboard.

3. Demonstrate to the pupils how to construct the *manometer*. Guide them in making measurements as directed to in the instructions.

Enrichment

Have the pupils construct a line graph showing the relationship between depth and pressure. Since pressure is directly proportional to depth, the resulting graph should be a straight line. By extending the line have the pupils conclude that the pressure at any depth may be predicted.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 25

Problem: How can the pressure in a liquid be measured?

Materials

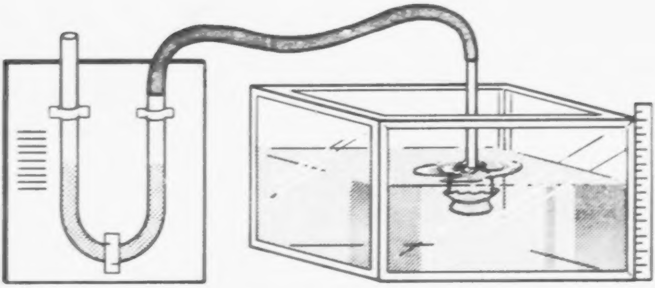
Thistle tube (short stem)
Balloon
Rubber bands
U-shaped glass tube
Rubber tubing (3 ft.) for U tube
Water
Food coloring
White cardboard
Wire
Ruler
Deep jar or aquarium
Medicine dropper

Procedure and Observation

1. Mix a few drops of food coloring with a little water. Using the medicine dropper, half fill the U-shaped tube with the colored water. The water level in each side of the "U-tube" should be even. Attach the "U-tube" to the stiff white cardboard following your teacher's instruction. Mark the water level in the tube on the cardboard.

2. Attach one end of the rubber tubing to one end of the "U-tube" and the other end of the tube to the thistle tube. (See diagram, page 166.)

3. Cover the end of the thistle tube with a piece of rubber from the balloon. Hold the rubber securely in place with rubber bands. Gently press down on the rubber. What happens? Why? What do you think will happen if we put the thistle tube under water?______________________



4. Fill the jar with water. Hold a ruler beside the jar and lower the thistle tube one inch into the water. Record the changes in the water level as you lower deeper in the water.

   NOTE: This instrument is called a ***manometer.***

DEPTH OF THISTLE TUBE IN JAR	WATER RISE IN OPEN TUBE
0 inches__________	__________inches
1 inches__________	__________inches
2 inches__________	__________inches
3 inches__________	__________inches
4 inches__________	__________inches
5 inches__________	__________inches

5. Point the thistle tube in different directions, keeping the depth the same. Does the water level in the "U" tube change?________________

Summary

1. What happens to the level of the water in the "U" tube as the manometer thistle tube is lowered in the water?
2. Why shouldn't the direction in which the thistle tube is pointing affect the water level in the "U" tube?

Homework

1. Why is there a limit to the depth that a submarine can dive?
2. What is a manometer?
3. How does a manometer work?
4. Write a laboratory report based upon this lesson.

26. HOW DOES DENSITY HELP EXPLAIN WHY OBJECTS SINK OR FLOAT?

Outcomes

- An object with a density greater than one, will sink in water.
- An object with a density less than one, will float in water.

Motivation

Prepare and demonstrate a Cartesian diver which may be made by adjusting the water level in a medicine dropper or small test tube so that it just floats. Place the diver into a 500 ml graduated cylinder, three-quarters filled with water. Stretch a piece of rubber sheeting tautly over the mouth of the cylinder and hold in place with rubber bands. Press the sheeting down to make the diver sink. Release the sheeting and the diver will rise. Ask, "How can you explain the behavior of the diver?" Call attention to the change in level of the water in the dropper or vial when it sinks.

Development

1. Using a graduated cylinder, measure out equal volumes of water, mercury, concentrated NaCl solution, glycerine, and alcohol.
2. Place each of these liquids into separate 500 ml beakers and label each with name of liquid and density.

	g/cc
a. water:	1
b. mercury:	13.6
c. concentrated NaCl:	1.1
d. glycerine:	1.3
e. alcohol:	0.8

2a. Demonstrate the hydrometer and show how it is used to determine the relative density (specific gravity) of a liquid.

3. To determine the effect of density of a liquid upon the floating and sinking of an object, have a pupil place an iron nail into each of the five beakers. Density of iron = 7.8 gm per cubic centimeter.

3a. Place an ice cube in each of the above. Have pupils make the observation that the density of ice is less than 1 gram per cubic centimeter (water) and more than .8 (alcohol).

4. Have the class observe that the nail sinks in all liquids but mercury.
5. Elicit that the iron is more dense than all the liquids in which it sank, but less dense than the mercury.
6. Display a hard boiled egg in shell labeled "Density: Approximately 1.1."
7. Have class predict those liquids in which the egg will sink and those in which it will float.
8. Allow a pupil to test the prediction.
9. Have the class generalize that:
   a. Objects will float in a liquid when the liquid is more dense than the object.
   b. Objects will sink in a liquid when the liquid is less dense than the object.
   c. Objects with a density greater than one will sink in water.

Summary

1. Explain the Cartesian diver in terms of its density.
2. Why do most woods float?

Homework

1. Construct a Cartesian diver using a medicine dropper, a milk bottle, and a balloon.
2. How is the submarine like the Cartesian diver?
3. *Why do helium-filled ballons float?*
   Hint: air may be considered to behave like a liquid.
4. *Why do steel ships float?*

Materials

Graduated cylinder
Water
4 500 ml beakers
Alcohol
Iron nails
Hard boiled egg

Mercury
NaCl
Glycerine
Small test tube
Rubber sheeting 6" x 6"
Medicine dropper
Rubber bands
Hydrometer
Ice cubes

27. WHAT HAPPENS TO THE WEIGHT OF AN OBJECT WHEN IT SINKS IN WATER?

Outcomes

- All objects appear to lose weight when submerged in water.
- The loss of weight of a sinking object is equal to the weight of the displaced water.

Motivation

Tell the story of Archimedes. "More than 2,000 years ago, the Greek scientist, Archimedes, noticed that while taking a bath, he appeared to lose weight or feel lighter and that the water level rose when he got into the tub. He wondered whether there was any connection between his apparent loss of weight and the rising of water."

Development

1. Display a spring scale, stone, string, and a beaker of water. Ask the class what happens to the weight of the stone when it is submerged in water. Have a pupil volunteer to solve this problem at the front while another pupil enters the findings on the chalkboard.
2. Repeat this with several other sinking objects to develop the generalization that sinking objects appear to lose weight in water.
3. Repeat this procedure using the aluminum density block. Direct the attention of the class to the change in the level of the water after the block is submerged.
4. Present the following to the class. "In each instance, the object submerged in water appeared to have lost weight. We have also

observed that the water has risen. Is it possible that the loss in weight and the rise of the water level are related?"

4a. *Using an object of known volume and a graduated cylinder, show that the volume of the displaced water equals the volume of the object.*

5. Ask the class to suggest possible tests for this hypothesis.

6. Define the change in the water level as displaced water, that is, that amount of water that the object is replacing.

7. Demonstrate how a catch bucket and an overflow can may be used to collect the displaced water for weighing.

8. Collect and weigh the displaced water for each object. Tabulate:

OBJECT WEIGHT IN AIR	OBJECT WEIGHT IN WATER	LOSS OF WEIGHT	WEIGHT OF DISPLACED WATER

8a. *Show that for objects whose volumes are known or can be calculated, the apparent weight loss in water can be predicted. For example:*

An aluminum block with a volume of 33 cm^3, and weight in air of 90 gms, will displace 33 cm^3 of water.

Since 33 cm^3 of water weighs 33 grams, the block will lose 33 grams and weigh 57 grams in water.

9. Based upon the above information, lead the class to the generalization that the loss of weight of a submerged object is equal to the weight of the displaced water.

Summary

1. What happens to the weight of an object when it is submerged in water?

2. When an object is submerged in a can, what happens to the water level?

3. What is the relationship between the weight loss of an object in water and the water displaced?

Homework

1. Explain why you can lift a person with one hand when you are in a swimming pool.

2. Fill in the following table:

OBJECT	WEIGHT IN AIR	WEIGHT IN WATER	WEIGHT OF DISPLACED WATER
stone	80 gms	50 gms	
metal rod		200 gms	50 gms
marble	100 gms		30 gms

3. *A block of lead has a density of 11.4 gms/cm^3 and a volume of 100 cm^3.*

   a. What does it weigh in air? *b. What does it weigh in water?*

4. *A block of aluminum and a block of lead both lose the same weight in water. What is the same about the two blocks?*

Materials

Spring scale	Aluminum density block
Stone and other objects	Graduated cylinder
String	Catch bucket
Beaker of water	Overflow can

28. WHAT HAPPENS TO THE WEIGHT OF FLOATING OBJECTS?

Outcomes

- A floating object appears to have zero weight in water.

- A floating object displaces an amount of water equal to its own weight.
- Heavy objects float lower in the water than light objects.

Motivation

A 40 ft. boat weighing 10,000 lbs. may be easily pushed away from the dock by one man. Why is it that he can move such a heavy object?

Development

1. Using a spring scale, have a student weigh a block of wood in air and record the weight.
2. Have the same block weighed in an overflow can. Collect the displaced water in a catch bucket.
3. Have a pupil record at the chalkboard the weight of the block in water (zero), its loss of weight, and the weight of the displaced water.
4. Repeat this with a different floating object.
5. From the data obtained, help the class to draw the conclusion that:
    a. Floating objects appear to have zero weight.
    b. Floating objects displace an amount of water equal to their own weight.
6. Identify the statement, "When an object is placed in water, the weight of the displaced water equals the loss of weight of the object," as ***Archimedes' Principle.***
7. Load a test tube with enough lead shot so that it floats upright in a large beaker.
8. Make a line with a wax pencil at the waterline of the test tube.
9. By adding small additional amounts of lead shot to the tube have the class observe that as more weight is added the tube floats lower in the water. Mark the new waterline each time.

9a. Show the relationship between the density of a floating object and how high it floats in water. A wood block with density equal to ½ gm/cm^3 will float half above and half below water.

10. **Draw an analogy between the floating test tube and a ship. As a ship is loaded, it sinks more deeply into the water. By observing the waterline we may estimate how large a load the ship is carrying.**

10a. ***Extend this idea to show how the weight of a ship may be determined by knowing its volume below the waterline.***

Summary

1. What does the weight of a floating object appear to be?
2. How much water does a ship that weighs 1,000 tons displace?
3. How can we tell if a ship is heavily loaded?

Homework

1. Fill in the following table:

OBJECT	WEIGHT IN AIR	WEIGHT IN WATER	WEIGHT OF DISPLACED WATER
Boat	10,000 lbs.		
Cork	100 gms.		
Log	700 lbs.		

2. How can we tell if an oil tanker is empty or loaded just by looking at it?

3. *If the density of polystyrene (foam plastic) is 1 gms/cm³ how much of it will float above the surface of water?*

4. *The density of seawater in the English system is about 64 lbs/ft³. A battleship displaces 1,500,000 cu. ft.³. How much does it weigh?*

29. CAN THE SAME OBJECT BE MADE TO FLOAT AND SINK?

LABORATORY LESSON

Outcomes

- An object that floats may be made to sink by changing its volume.

Motivation

The weight of a steel battleship is stated in tons. A typical battleship weighs 45,000 tons. "Why is it that such a heavy object can float and a small bar of steel sinks?" Discuss this briefly, and indicate that this problem will be studied in the laboratory.

Development

1. Distribute Laboratory Worksheets and material.
2. Read Worksheet aloud with class.
3. Caution pupils to make accurate measurements.
4. Direct class to begin summary questions after lab.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 29

Problem

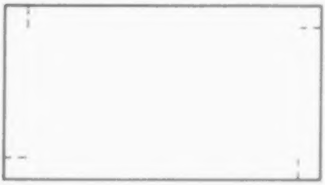
Can the same object be made to float and sink?

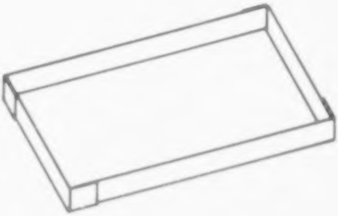
Materials

Ruler
Trough filled with water
Scissors
Aluminum sheet 5" x 7" (foil from frozen TV dinner may be used)
Strips of lead (2" x 1")

Procedure and Observation

1. Using the diagram below, make the following 1" cuts on the aluminum sheet. Be careful, the corners of aluminum may be sharp.





2. Fold up the sides of the aluminum sheet and bend over the cut ends so that they form a box.

3. Place the aluminum box in the water. Write what you see in the summary table.

4. Carefully place several strips of lead in the middle of the aluminum sheet. What happened? ____________________.

5. Remove the box from the water and record its length, width, and height in the summary table.

6. Flatten out the aluminum sheet and fold it in half. Fold it in half three more times. Place the aluminum in the water and write your observations in the summary table.

7. Remove the object from the water and measure its length, width, and height. Record in summary table.

8. Calculate the volume (how much space it takes up) of the aluminum (sides folded) and the volume folded in half four times. Enter these results in the summary table. (Remember: Volume = Length × Width × Height.)

Summary Table

Item	Floats or Sinks	Length, Width, Height	Volume (L x W x H)
Aluminum sheet (sides folded)			
Aluminum sheet (folded four times)			

Summary

1. In this lesson, what did the volume of an object have to do with whether it would sink or float? ____________________________________

2. When you measure the volume of the floating aluminum boat, what are you including in your volume? Aluminum + ____________________________

3. When you measure the volume of the folded aluminum sheet, the volume is composed only of ____

4. Compare the density of aluminum plus air to the density of aluminum alone. ____

5. Would ships float if they were solid metal? ___________________________

Homework

1. A submarine can be made to sink or float by controlling the amount of water in its tanks. Explain.
2. Why is it important to have watertight compartments in ships?
3. Why are barges used to carry heavy loads?
4. What is the danger of having too many people in a rowboat?

30. *WHAT IS ARCHIMEDES' PRINCIPLE?

LABORATORY LESSON

Outcomes

- Objects that sink displace an amount of water equal to their loss of weight in water.
- Objects that float displace an amount of water equal to their weight in air.

Motivation

If you fill your bathtub all the way up to the top and then get in, how much will the spilled water weigh?

Development

1. Distribute the Worksheets and read them with the class.
2. Demonstrate proper method for using overflow can and catch bucket. Pay particular attention to filling of the overflow can.
3. Distribute materials and guide pupils in solving problems.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 30

Problem: What is Archimedes' Principle?

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* Only for classes programmed for 5 periods.

Materials

Overflow can
Catch bucket
Spring scale (0-250 gms)
String
Small wooden block
Small metal block

Procedure and Observation

1. Hold your finger over the spout of the overflow can and fill it with water above the level of the spout.

2. Place the can on the table. Put the catch bucket under the spout, and remove your finger. When water no longer flows from the spout, discard what has fallen into the catch bucket.

3. Weigh the metal block and the empty catch bucket on the spring balance. Make a record of this and all of your findings.

4. Place the catch bucket under the spout, and place the metal object into the water of the overflow can. Find the weight of the object while it is completely immersed.

5. Find the weight of the catch bucket with the displaced water.

6. a. Weight of object in air__________________ grams.
   b. Weight of object in water__________________ grams.
   c. Loss of weight of object in water__________________ grams.
   d. Weight of catch bucket with water__________________ grams.
   e. Weight of empty catch bucket__________________ grams.
   f. Weight of displaced water__________________ grams.

7. Weigh the block of wood on the spring balance.

8. Fill an overflow can with water to the spout and place the block of wood in the can.

9. Collect the displaced water in the catch bucket and weigh the catch bucket and water.

10. Discard the water in the bucket and weigh the empty catch bucket.

11. a. Weight of wood in air__________________ grams.
    b. Weight of catch bucket and water__________________ grams.
    c. Weight of empty catch bucket__________________ grams.
    d. Weight of displaced water__________________ grams.

Summary

1. An object weighs 10 grams and displaces 3 grams of water. How much does the object weigh in water?__________________

2. What is the relationship between an object's weight in water, and the displaced water?__________________

3. A block of wood weighing 2 lbs. in air is made to float in water. How much will the displaced water weigh?

Homework

1. State Archimedes' Principle.
2. Why is it important to know the weight of the empty catch bucket?
3. Write up a lab report based upon today's lesson.

Appendix

SUGGESTED REFERENCES

Teacher

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Pupil

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ENRICHMENT ACTIVITIES

Subject Matter

1. Albert Einstein first showed how mass and energy are related to the formula $E = MC^2$. Expand the conservation laws to include this concept.
2. Analyze combinations of simple machines to find the fulcrums, effort arms, resistance arms, total mechanical advantage, etc.

3. Show how the law of moments operates in the equal arm balance and in the triple beam balance.
4. Develop the concept of efficiency in simple machines.

$$E = \frac{\text{work out}}{\text{work in}} \times 100$$

Pupil Projects

1. Build a ship model that operates on a solar cell.
2. Build a model of a waterwheel. Find the most efficient design.
3. Find out what happens to a spring as you exceed its elastic limit.

Trips

1. Con Edison Energy Distribution Center
2. Con Edison Indian Point Atomic Reactor
3. Any construction site to see simple machines

Research

1. The search for perpetual motion.
2. Einstein and atomic energy
3. Madame Curie and radioactivity
4. Torricelli and air pressure
5. Archimedes and buoyancy
6. Robert Hooke and elasticity
7. Sir Isaac Newton and gravity
8. Bequerel and the discovery of radioactivity

TEST QUESTIONS

Completion

A. Write the word or expression that best completes the statement:

1. The energy of streams, wind, and running water, is called __________ energy.
2. The wasted energy in machines is converted into __________ energy.
3. A __________ is a push or a pull.
4. The __________ of a spring is proportional to the weight suspended from it.
5. Force times distance equals __________.
6. On rough surfaces work is wasted overcoming __________.
7. Mechanical advantage is the number of times a force is __________.
8. The __________ is an example of an inclined plane.
9. All objects fall toward the __________ of the earth.
10. Density equals weight divided by __________.
11. Pressure increases with __________ in water.
12. __________ has a density of one gram per cubic centimeter.
13. The manometer measures __________.
14. Objects with a density less than one __________ in water.
15. When floating, a 15 ton boat displaces __________ tons of water.

B. Complete the sentences below, using the following words (a word may be used more than once):

energy force distance work
conservation form destroyed

1. The entire universe, as viewed by a physicist, is composed of two things, matter and __________.
2. The "Law of __________ of energy" states that energy can neither be created nor __________, but can only be changed.

3. To measure the amount of energy used to move an object, a physicist uses the concept of____________.

4. ____________is defined as the ability to do work.

5. To find the work done you multiply the____________by the ____________.

C. Complete the statements below, using the following words:

simple machines
fulcrum
effort arm
balance
base
rotate
resistance arm
center of gravity

1. The lever, pulley and inclined plane are all____________.

2. The point that an object turns about is called the____________.

3. When the moments of force on a body are unbalanced, the object will____________.

4. When the center of gravity is not within the____________the object will tip.

5. The distance from the effort to the fulcrum is called the ____________.

6. The distance from the resistance to the fulcrum is called the ____________.

7. An object turns most easily about its____________.

8. When the moments of force on both sides of an object are equal, the object will____________.

Multiple Choice

Write the letter preceding the correct answer in the space at the left.

__________ 1. Heat is a form of (a) force (b) energy (c) matter (d) metal.

__________ 2. Turbines change (a) heat energy to light energy (b) water to steam (c) mechanical energy to electrical energy (d) water to ice.

__________ 3. Energy can never be (a) changed in form (b) manufactured (used) (d) created or destroyed.

__________ 4. A dry cell changes (a) chemical energy to electrical energy (b) mechanical energy to work (c) motion into energy (d) light into heat.

__________ 5. Centimeters measure (a) force (b) work (c) pressure (d) length.

__________ 6. A force is a (a) motion (b) push (c) form of matter (d) form of energy.

__________ 7. A spring can be used to measure (a) weight (b) density (c) volume (d) momentum.

__________ 8. Work is done when (a) a force is applied (b) an object moves (c) a force causes motion (d) energy is used.

__________ 9. To measure work you need a (a) bunsen burner (b) ruler (c) spring scale and ruler (d) slide rule.

__________ 10. The center of gravity (a) is in the same place for all objects (b) is equal to the work done (c) appears to be where all the weight appears to be concentrated (d) is never in the center of an object.

__________ 11. When an object is supported from its center of gravity it is (a) turning (b) balanced (c) doing work (d) moving.

__________ 12. Objects turn most easily about their (a) ends (b) focal points (c) fulcrum (d) center of gravity.

__________ 13. A lever (a) is always supported at its center of gravity (b) uses a small amount of work to perform a large amount of work (c) always has a fulcrum (d) never does work.

__________ 14. The mechanical advantage of a lever with a resistance arm of 2 ft. and an effort arm of 4 ft. is (a) 1 (b) 2 (c) 0 (d) 4.

__________ 15. When the effort arm of a lever is lengthened, you (a) increase the M.A. (b) decrease the M.A. (c) make the M.A. zero (d) do not change the M.A.

__________16. When the moments on the left-hand side equal the moments on the right-hand side, a meterstick will (a) spin (b) fall (c) balance (d) produce energy.

__________17. An example of an inclined plane is a (a) pulley (b) Hall's carriage (c) ramp (d) wheel.

__________18. A pulley can (a) change the direction of a force (b) increase a force (c) do work (d) do all of these.

__________19. All objects fall (a) with different speeds (b) toward the center of the earth (c) 10 M.P.H. (d) toward the magnetic poles.

__________20. To find density divide (a) weight by volume (b) force by area (c) pressure by depth (d) volume by weight.

__________21. Ten feet below the surface of a lake, the water pressure is (a) maximum (b) minimum (c) twice the surface pressure (d) the same in all directions.

__________22. An iron nail will (a) dissolve in mercury (b) float on water (c) sink in mercury (d) float on mercury.

__________23. The desity of mercury is closest to (a) .13 grams/cm^3, (b) 1.3 grams/cm^3 (c) 13 grams/cm^3 (d) 130 grams/cm^3.

__________24. To measure the pressure in a liquid, use a (a) barometer (b) thermometer (c) hydrometer (d) manometer.

__________25. Objects which sink in water have a density in grams/cm^3 of (a) greater than one (b) less than one (c) two (d) zero.

__________26. Objects that float on water have a density in grams/cm^3 of (a) less than one (b) twice the density of water (c) more than one (d) 14.7.

__________27. Ten cubic centimeters of a material weigh 10 grams. It is most likely (a) alcohol (b) glycerine (c) carbon tetrachloride (d) water.

__________28. A block of aluminum 10 cm × 10 cm × 10 cm weighs (a) 1000 grams (b) 500 grams (c) 2,700 grams (d) 13,600 grams.

__________29. A block of wood 23 cm × 10 cm × 4 cm weighs 410 grams. The amount of water it will displace is (a) 1840 grams (b) 920 grams (c) 205 grams (d) 410 grams.

__________30. An iron block 5 cm × 5 cm × 5 cm weighs 1000 grams. The amount of water it will displace is (a) 125 grams (b) 250 grams (c) 500 grams (d) 1000 grams.

True — False (Modified)

Identify as TRUE if the statement is correct; if the statement is not correct, change the underlined word or phrase to make the statement true.

1. Energy can neither be created nor destroyed.__________
2. Liquids and gases in motion produce chemical energy. __________
3. Motor oil is added to an automobile engine to increase friction. __________
4. A force always does work.__________
5. A force is a push or a pull.__________
6. Work is found by multiplying the force by the distance. __________
7. Objects balance at the fulcrum. __________
8. The point in an object about which it turns most easily is called the center of gravity.__________
9. A lever multiplies work.__________
10. A meterstick will turn if the moments on the right side equal the moments on the left side.__________
11. All objects fall toward a point in the Arctic Ocean.__________
12. An iceberg is less dense than water.__________
13. The pressure in a liquid is lowest at the bottom.__________
14. Iron will sink in mercury.__________
15. A floating object displaces an amount of water equal to its volume in air.__________

Matching Test

Fill in the letter of the words in Column II which best matches the statement in Column I.

COLUMN I	COLUMN II
____1. conversion	A. forms of energy
____2. dry cell	B. wastes energy
____3. heat, light, sound	C. turbine
____4. friction	D. energy change
____5. pinwheel	E. conservation of energy
	F. chemical to electrical energy

____1. force	A. ability to do work
____2. center of gravity	B. instrument for measuring
____3. work	C. push or pull
____4. energy	D. place where weight appears concentrated
____5. spring	E. unit of measurement
	F. force × distance

____1. lever	A. inclined plane
____2. effort arm	B. turning point
____3. ramp	C. $\frac{\text{effort}}{\text{resistance}}$
____4. fulcrum	D. $\frac{\text{resistance}}{\text{effort}}$
____5. mechanical advantage	E. seesaw
	F. distance from effort to fulcrum

____1. density	A. law of floating and sinking objects
____2. pressure	B. force due to gravity
____3. weight	C. force of attraction between two objects
____4. gravity	D. energy
____5. Archimedes	E. weight/unit volume
	F. force/unit area

Diagrams

1. Show on a labeled diagram the energy changes that take place in an electric buzzer.
2. Show with a diagram how a spring would look supporting the following weights: 50 gms, 100 gms, 200 gms, 400 gms, 800 gms.
3. Draw the following simple machines and label the fulcrum, effort arm and resistance arm; nutcracker, pliers, crowbar.
4. Explain, with the aid of a labeled diagram, how the "Cartesian Diver" works.

Essay

1. By applying the Law of Conservation of Energy, write a paragraph explaining whether the following statements are *true* or *false*.
   a. The universe has more energy than ever before.
   b. An outstanding feature of man is that he has created energy on Earth.
   c. Matter is changed to energy in an atomic pile.
2. Explain how it is possible to use energy to produce a force but not do any work.
3. What are some of the problems that you might encounter if you had to build a submarine?
4. Explain how the weight of a heavy ship can be found.
5. A man finds the road blocked by a 500 lb. rock. Name the two simple machines that he could use to help him move it. Show how he should set up these machines.

Unit III

BIOLOGY

Digestion and Absorption

Circulation and Respiration

Excretion

Behavior

DIGESTION AND ABSORPTION

Suggested Lessons and Procedures

1. WHERE DOES THE FOOD GO AFTER IT IS SWALLOWED?

Outcomes

- The digestive tract is like a tube, or pipe, open at both ends.
- Food is moved through the tube by the muscular action of the tube itself.
- The digestive tract is divided into these main parts: the mouth, esophagus, stomach, small and large intestines.

Other parts of the digestive system include the following: salivary glands, gastric glands, liver, pancreas, gall bladder, and intestinal glands.

Motivation

When the whale swallowed Jonah, did Jonah become part of the whale?

Development

1. Demonstration with bioscope:
    a. Prepare a slide with either a Daphnia (water flea) or a tubifex (worm) to be used with the bioscope. Daphnia or tubifex may be obtained from the local pet shop.
    b. To the container of live Daphnia, or tubifex, add a yeast culture

stained with neutral red. (The exercise is still valuable without the yeast culture.)

NOTE: This should be done about 5 minutes before the class views the Daphnia.

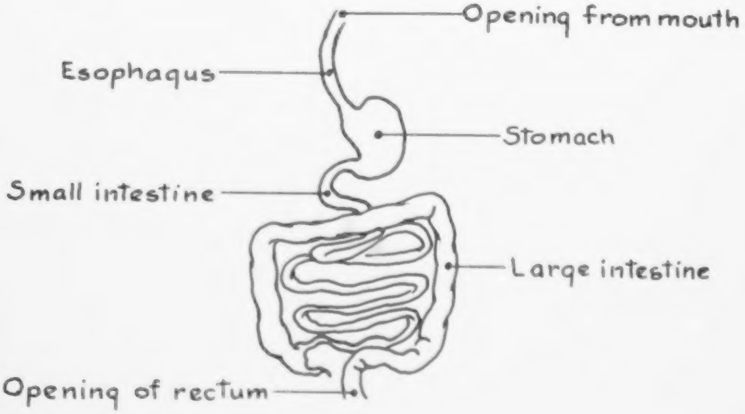
c. A single Daphnia or tubifex may be removed with a medicine dropper and placed in a depression slide for demonstrating. Remove most of the water to slow down the movements of the Daphnia or tubifex.

d. Pupils may observe the passage of yeast cells through the gut. They should observe a change in color.

2. Guide the pupils to conclude from this demonstration, that the digestive tract is continuous, is open at both ends, and that food is moved through the tube by the muscular action of the tube itself.

NOTE: It is not necessary to discuss peristalsis now.

3. Prepare, duplicate, and distribute a labelled diagram of the human digestive tract.



Using both a wall chart and a manikin, help pupils identify the parts of the digestive tract.

3a. Locate and discuss the functions and structure of the digestive glands.

Summary

1. Using the chart, have the pupils trace the path the food would follow, naming the parts from mouth to rectum in correct order.

1a. Point out that the salivary glands, liver, gall bladder, and pancreas have "tubes" which lead into the digestive tract.

2. How are the digestive tubes of Daphnia and of a human alike, and how are they different?

Homework

1. Why is the digestive tract called a "food tube"?

1a. What is the difference between the terms "digestive tract" and "digestive system"?

2. What must happen to the food in the food tube so that it can get to the other parts of the body?

3. Define the term "alimentary canal."

4. Locate any objects at home that are similar to the "tube within a tube" construction of our digestive tract.

Materials

Bioscope
Medicine dropper
Tubifex or Daphnia
Depression slide

Duplicated diagrams of human digestive tract
Manikin
Charts of digestive system

2. HOW IS FOOD CHANGED IN THE MOUTH?

Outcomes

- Digestion is the gradual changing of food into small, soluble particles.
- Digestion of food begins in the mouth.
- Food is broken into smaller pieces by the teeth.

- Saliva is the liquid in the mouth which moistens food.
- A chemical substance, called an enzyme, is found in saliva. This enzyme digests starch.
- Chemical and mechanical digestion take place in the mouth.

Motivation

Distribute a sodacracker to each of two pupils. Ask them to chew the crackers without swallowing.

Development

1. Briefly review with the class the names and roles of the various nutrients essential to the body (especially sugar and starch).

1a. Discuss the function of the epiglottis in preventing the food from entering the trachea. Discuss the value of being able to taste foods, the function of the lips, tongue, specific teeth, and the act of swallowing.

Tell pupils that the childhood disease known as "mumps" is caused by an infection of the salivary glands.

2. Ask the pupils why the crackers are being chewed and have them state the trends of changes that might occur. Ask the pupils who did the chewing to describe any changes they have noticed.

3. Have pupils describe the parts of the mouth that are involved in the breakdown of the cracker.

   The main parts should include the teeth, the tongue, and the salivary glands (which produce saliva). Pupils should understand that food is made into smaller pieces by the teeth, moistened by the saliva, and mixed with the saliva by the tongue.

4. The chemical changes in the above may be illustrated by the following demonstration:

   a. Prepare 5 test tubes ⅓ full of 1% starch suspension and test one for the presence of starch (using Lugol's solution).
   b. Have a pupil who has washed his mouth add his saliva to another test tube and place it in a beaker of warm water (37°C).
   c. The third tube (containing no saliva) is placed in warm water

also. This is a *control* (review this word by asking what use the third tube has).

d. Add saliva to the fourth test tube and place it in a beaker of cold water.

e. The fifth test tube (with no saliva) is placed in cold water. Allow all the test tubes to remain this way for 5 minutes. Ask the class for possible outcomes of this demonstration.

5. After a while the pupils should observe the suspensions in both tubes and note the relative clearing of the tube with the added saliva. Ask, "What do you think brought about the change?" Also ask, "What effect did the temperature have on the change?"

6. Tell the pupils that a chemical substance called an *enzyme* caused the clearing in that the starch was changed into a soluble substance. This enzyme is found in the saliva (which they may know as spit).

6a. Identify the enzyme (ptyalin) and explain that enzymes are protein in nature and play an important part in many life processes.

You may allude to the practice of desert travellers or runners, keeping a small object (such as a button or stone) under their tongues to maintain the moisture in their mouths.

7. Show mechanical digestion by the following demonstration:

Set up two test tubes with equal parts of water. Take two cubes (lumps) of sugar. Crush one lump into a powder. Add the powdered sugar to one test tube, and place the solid lump of sugar into the other tube. Shake both tubes briefly.

Observe the length of time it takes for the sugar to dissolve in each test tube.

"What effect did powdering the sugar cube have on the time needed to dissolve?" Refer back to Grade 8 Chemistry unit on rate of solution (break into smaller pieces). Ask "What structures in the mouth help to break down food into smaller pieces?"

8. Mention the fact that many animals have little or no mechanical digestion, e.g., a python may swallow a whole young pig and then lie quietly for a week or more while the pig is being digested.

Also, a frog will swallow a whole fly. Ask "Why can't the frog break down the fly into smaller pieces in the mouth?"

Summary

1. What parts of the mouth help to digest food?
2. What are the two types of digestion that take place in the mouth?
3. What is involved in each of the above processes?
4. Is it a good health rule to chew your food thoroughly? Explain.

Homework

1. At home, take a piece of bread and chew it for 5 minutes. Describe what happened to the taste. How do you explain this?
2. What is the difference between mechanical and chemical digestion? Give an example of each.
3. *Why do some birds and earthworms swallow small pebbles?*

Materials

Bottle of starch solution
Bottle of Lugol's solution
8 test tubes
Test tube rack
Two beakers
Marking pencil
2 cubes of sugar
Cold and warm water

3. HOW IS BREAD CHANGED IN YOUR MOUTH TO TASTE LIKE CAKE?

LABORATORY LESSON

Outcomes

- There is a chemical reaction between starch and saliva, whereby saliva changes starch to sugar.
- *The action of saliva on starch is speeded up when the temperature is increased.*
- Not all the starch is changed to sugar in the mouth.

Motivation

Ask pupils to recall the taste of the bread they chewed for 5 minutes (homework).

Development

Pupils will get a chance to review past learnings on chemical and physical changes and nutrient testing.

1. Review the difference between a physical and a chemical change. Elicit the fact that food undergoes a physical change (size and shape) through the action of the teeth and the tongue.
2. The changing of starch into a soluble substance by the action of saliva, observed in previous lesson, should be related to *chemical change.*
3. Have pupils recall that the bread became sweeter as they chewed it. Tell pupils that the experiment they will do should be able to explain how the bread was changed to taste like cake?
4. Distribute materials and Worksheets.

4a. You may want to have one-half of class work with warm water, the other with cold water.

NOTE: *Teacher should heat water before class starts.*

5. After the pupils have completed the activities on the Worksheet, have them conclude that saliva causes a chemical change of starch to sugar. You may explain that test tube No. 3 (starch and saliva) also showed the presence of starch, because not all the starch has been changed chemically by the saliva.

Summary

1. A few drops of Lugol's solution (or dilute iodine) was added to a liquid in a test tube. The liquid took on a blue-black color.

   What did this color change tell us about the solution in the test tube?

1a. Based on the additional investigations, what effect would varying amounts of saliva, starch or sugar have on the degree of color changes.

2. Saliva was then added to the same solution. The blue color gradually disappeared. Explain.

2a. Discuss the relationship of the amount of chewing to the rate of change of the starch to sugar.

Homework

1. With your parents' permission, use dilute iodine to see which of the following contain starch: onion, potato, bread, cake, apple.

1a. By means of a diagram, indicate where the salivary glands are located.

2. How could you tell which foods contain more starch than others?

3. Why would it be difficult to swallow without saliva?

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 3

Problem: What chemical change takes place when saliva is added to starch?

Materials

Test tube rack
4 test tubes
Test tube holder
Marking pencil
Alcohol burner

Bottles of: Starch suspension
Lugol's solution
Benedict's solution
Beaker of warm water

Procedures

1. Mark the test tubes 1, 2, 3, 4 with your marking pencil.

2. Fill all the test tubes ¼ full with the starch suspension.

3. Place about ½" of saliva in test tubes #3 and #4.

4. Place test tubes #3 and #4 into beaker of water.

5. Add Benedict's solution to test tubes #2 and #4 and heat them over the alcohol burner.

   Benedict's solution is being used to test for the nutrient________________.

   If this is present, the solution will turn________________.

6. Add Lugol's solution to test tubes #1 and #3.

   Lugol's solution is being used to test for the nutrient________________.

   If this is present, the solution will turn________________.

7. Complete chart to indicate what has taken place. (See next page.)

8. Have pupils perform additional tests to determine how varying amounts of starch, sugar, and saliva affect the degree of color change.

TEST TUBE	CONTAINS	OBSERVATIONS	CONCLUSIONS
# 1	starch, Lugol's solution		
# 2	starch, Benedict's solution		
# 3	starch, saliva, Lugol's solution		
# 4	starch, saliva, Benedict's solution		

9. Explain why a piece of bread tastes sweeter after it has been chewed for a while.

4. HOW DOES FOOD MOVE DOWN THE DIGESTIVE CANAL?

Outcomes

- Food moves down the esophagus (gullet) to the stomach.
- Peristalsis is the process by which the muscular action of the esophagus pushes the food down the esophagus.
- Peristalsis usually moves the food in only one direction.
- Food is squeezed and mixed thoroughly while in the stomach.
- Food is "stored" in the stomach.
- The squeezing, or churning action of the stomach muscles plus the chemical action breaks the food down into smaller pieces.

Motivation

What hurts you when you are hungry? Tell pupils to place their hands over their stomachs.

Development

1. Encourage pupil volunteers to show where stomach is located (left side near waistline).

2. Ask them, "How does food get from your mouth to your stomach?" Have pupils recall from Lesson 1 that food passes down the esophagus to the stomach.

3. Tell pupils that the movement of the food through the esophagus is caused by muscular action (contraction) of the esophagus.

4. Illustrate the contraction of the esophagus by demonstrating the following model:

   a. Place a few drops of glycerine in the end of a piece of rubber tubing.

   b. Push the marble into this end of tubing.

   c. Squeeze the tube behind the marble until the marble comes out the other end.

5. Encourage pupils to explain what they saw. Elicit that the muscles of the esophagus "push" the food as we pushed the marble along the rubber tube by squeezing.

   Challenge pupils to explain how this special contraction answers the question how we can eat or drink standing on our heads.

6. Tell pupils that this muscular action of the food tube is called ***peristalsis***. Explain further that this action usually goes in one direction. Relate this to the movement of the "slinky." Demonstrate the movement of the "slinky" to illustrate this.

7. Have pupils understand that on occasion peristalsis does go backward, as when they vomit, or "throw up".

8. Refer pupils to a chart of the digestive system. Have them examine the stomach on this chart. Ask them why the stomach is sometimes referred to as a food "bag." They should conclude that its thickness and shape make it suitable for storing food.

9. Have them realize that it is muscle tissue, and therefore can squeeze and churn the food that enters it. This "churning" helps break the food down into smaller pieces.

10. *Prepare a small beaker with some food and a dilute solution of acid. Allow it to stand awhile. Have pupils observe mixture and explain the appearance of the mixture.*

11. *If time permits, compare the human stomach with that of a cow, bird, etc. Elicit how each is adapted to satisfy the animal's food needs.*

Summary

1. What part of the "food tube" does the food enter immediately after swallowing?
2. What happens to food in the esophagus?
3. What is the process or action that moves the food along the esophagus called?
4. What part of the food tube does the food enter from the esophagus?
5. What is the shape and makeup of the stomach?
6. Where does the food remain longer, in the mouth or stomach?

Homework

1. How is the food moved along the esophagus?

1a. Explain how astronauts who work where gravity is decreased, have no trouble with their food moving along their digestive tracts.

2. Explain how the acrobat can drink water while standing on his head.

2a. How does the stomach differ from the esophagus in shape and function?

3. How does the stomach make food smaller?
4. How do farmers get butter from their milk?
5. Why is it important that the muscles of the esophagus move in one direction only?

Enrichment

Explore the effect of different factors which may influence the digestive system, as for example:

a. emotional situations (examinations, arguments at the dinner table)

b. diets and food fads

c. exercise (before and after eating)

Materials

Glycerine
Rubber tubing
Marble
"Slinky"
Chart of digestive system

NOTE: Twenty-four hours in advance of Lesson 6, prepare the following demonstration materials:

7 test tubes
2% HCl
egg white
cotton
Pepsin
Vegetable oil

a. Add to 4 test tubes, egg white of same-sized pieces, *and* in an amount sufficient to cover

#1 — water
#2 — HCl (2%)
#3 — Pepsin (1%)
#4 — Pepsin and HCl

b. Add to 3 test tubes, vegetable oil, *and*

#5 — Saliva } (Save for Lesson 7, also)
#6 — Pepsin and HCl }
#7 — Vegetable oil only

c. Plug the test tubes with cotton, label, and set in a warm place (37° to 40° C for 24 hours.

5. *WHAT FOOD TESTS CAN WE PERFORM IN THE LABORATORY?

LABORATORY LESSON

Outcomes

- There is sugar in sugarless gum.
- Cooking, and washing afterwards, reduces the amount of starch in starchy foods.
- There is no sugar in dietetic soda.

Motivation

Why do people drink dietetic sodas?

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* Only for classes programmed for five periods

Development

1. Ask pupils if it is possible for us to determine how much food nutrient is in the dietetic soda and the regular soda. Suggest further that we can determine the amount of other nutrients in foods when cooked and uncooked.
2. Tell pupils that we are going to test some foods to see if the amount of nutrient in the food differs.
3. Distribute pupil worksheets and guide pupils in carrying out the procedures.

Homework

1. Ask anyone in your home if they diet. Find out if they are dieting to gain weight, or to lose weight. What must be done in order to gain, and to lose?
2. List at least 5 items that are on the market as dietetic food and drink.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 5

Problem: Why are dietetic foods used in diets?

Materials

Uncooked rice
Cooked rice
Water from cooked rice
Sugarless gum
Regular gum
Dietetic soda
Regular soda
8 test tubes and test tube holders
Test tube rack
Benedict's solution
Lugol's solution
Burners

Procedure

1. Prepare eight (8) clean, labeled test tubes.
    - a. Place into the first tube a rolled piece of sugarless gum.
    - b. Place into the second tube a rolled piece of regular chewing gum.
    - c. Cover the gum in each tube with water.
    - d. Add 5 cc of Benedict's solution to each tube and heat gently over a burner.

e. Observe any changes that occur, and record.

2. Place into test tubes #3 and #4:
   a. 5 cc of dietetic soda.
   b. 5 cc of non-dietetic soda.
   c. Add 5 cc of Benedict's solution to each tube, and heat gently over a burner.
   d. Observe any changes that occur and record.

3. Place into test tubes #5, 6, 7, and #8
   a. a few grains of uncooked rice (5)
   b. a few grains of cooked and washed rice (6)
   c. 5 cc of the water washed off from the cooked rice (7)
   d. 5 cc of the water from the uncooked rice. (8)
   e. Add a few drops of Lugol's solution into each test tube.
   f. Observe any changes that occur and record.

Summary

1. Does sugarless gum contain sugar?

   How do you know?

2. Which piece of gum showed the best test for sugar?

   Why?

3. Why do people drink dietetic sodas? Explain.

4. If you needed to gain weight, which kind of soda would you drink?

5. Which of test tubes #5 and #6 gave the most positive test?

   What happened to some of the starch of the cooked rice?

6. Why do you think your parent washes and drains rice after cooking it?

---

7. Explain why dietetic foods are becoming so popular in this country.

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6. HOW ARE PROTEINS DIGESTED?

Outcomes

- The stomach moistens food and makes it smaller.
- The stomach lining gives off a liquid called gastric juice.
- Gastric juice is made up of water, hydrochloric acid, and enzymes (one of which is pepsin).
- *Rennin assists in the digestion of milk proteins by coagulation of casein.*
- Protein foods undergo a chemical change to a more soluble substance when they are mixed with gastric juice.

Motivation

Point out to pupils that many scientific discoveries have been made by accident. Relate the story of Dr. Beaumont and his patient, Alexis St. Martin.

Development

1. Ask the pupils what they think happens to food in the stomach.
2. Elicit from pupils that the food is being broken down both physically and chemically in the stomach.
3. Call on pupils to examine a piece of tripe with a hand lens. Tell the class that the tripe is the stomach lining of a cow. Have pupils tell what they saw.
4. Much can be learned about the stomach, through demonstrations. Explain how demonstration materials were prepared.

5. **Demonstrate the digestion of egg white (protein) by gastric juice. Elicit from pupils that this juice helps digest the food as does saliva in the mouth. Use the materials prepared 24 hours earlier. Save these materials for Lesson 7 also. Refer to NOTE at end of Lesson 4 for further information.**

5a. Demonstrate coagulation, or curdling of milk with rennin. Explain that rennin is also found in gastric juice.

6. Have pupils observe what happened. Why did a change occur in tubes #3 and 4? Of these two tubes, where was the greater change? Why?

7. Ask pupils why there was no change in tubes #1 and #2. What is necessary for a chemical change to occur in the stomach?

8. Have pupils conclude from the story of Dr. Beaumont's experiments, and their observations of the demonstration test tubes, that:
    - a. the stomach gives off a juice called *gastric juice*
    - b. gastric juice contains enzymes (one of which is pepsin), hydrochloric acid, and water
    - c. the enzyme, in the presence of hydrochloric acid, causes a chemical change and breakdown of the food.

8a. Have pupils speculate on what may happen when there is an increase in hydrochloric acid concentration in the stomach. Elicit pupil suggestions as to why the hydrochloric acid does not "burn" through the stomach wall.

Summary

1. What happens to protein foods in the stomach?
2. What are the substances found in gastric juice?
3. Why did the meat in Alexis St. Martin's stomach become smaller?
4. How can we find out what parts of gastric juice act on protein foods in the stomach?

Homework

1. Explain what happens to meats and other protein foods in the stomach.

2. Make a list of 5 protein foods in your home. Compare the price of these foods with foods that contain mostly starch.
3. List the makeup of gastric juice.
4. Why do you think people may have "acid" indigestion?
5. *Explain what may be the cause of stomach ulcers.*
6. *Using appropriate references, draw a diagram of the human stomach. Label and describe the structure of the stomach.*

Materials

Fresh tripe	See Lesson 4 NOTE
2 hand lenses	for additional materials

7. WHAT HAPPENS TO FATS IN THE SMALL INTESTINE?

LABORATORY LESSON

Outcomes

- Digestion of nutrients is more effective when the size of the particles is smaller.
- Bile is a chemical made by the liver.
- Emulsification of fat by the bile makes digestion of fats easier since the "droplets" of fat are made smaller.

Motivation

Recall why it is helpful to use soap to wash our hands or to wash greasy pots and dishes.

Elicit from the chemistry unit that soap helps to emulsify (break up) the larger grease particles.

Development

1. Have pupils examine the previously prepared test tubes containing the saliva — vegetable oil, and the gastric juice — vegetable oil.

   Have them observe by comparing it to the untreated vegetable oil, that the vegetable oil has not been digested.

2. Display a chart of the small intestine with the liver, pancreas, and intestinal glands. Locate the gall bladder and intestinal glands and point out that all three organs are connected to the small intestine. Show a sample of artificial ***bile*** and point out that the liver makes this digestive juice while the gall bladder stores it.
3. Tell the pupils that the experiment they are about to do will help them see the effect of bile on fat. A 5% solution of bile salts (or an oxgall suspension) may be used for the bile.
4. Distribute the Worksheets and materials. Guide the pupils in performing this investigation.
5. After the laboratory work, review with the pupils (from Chemistry — 8th grade) that the mixtures they have made are emulsions.

   They should observe that a more permanent emulsion is made when the bile was added to the oil and water.

   Have them conclude that the oil has been divided into small droplets within the water. Ask, "Is this change to smaller particles a chemical or a physical change? Why?"

Summary

1. Why is emulsification of the oil called a physical change?
2. Why does breaking the oil drop into smaller droplets make it easier for digestion?
3. Why do we shake the test tubes?

Homework

1. What organ of our body makes bile?
2. Could we live without the gall bladder? Explain.
3. Why does dirt come off our hands easier when we use soap?

Enrichment

1. *Under a microscope, have the pupils examine and compare a drop of oil before and after emulsification, as follows:*
   a. *Place a drop of liquid obtained from oil and water mixture on a slide. Examine under the microscope.*

   b. ***Repeat with a drop taken from oil and bile mixture.***

   c. ***What differences were noted?***

2. ***As an additional assignment, ask:***

   a. ***What are "gallstones"?***

   b. ***What are some foods people must avoid eating when they have a "gallbladder" condition? Why?***

   c. ***The physical digestion of nutrients to smaller particles may be accomplished by__________, __________, and __________.***

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 7

Problem: What does bile do to fat?

Materials

Test tube rack	Two medicine droppers
Two test tubes	Marking pencil
Dropper bottles of oil, water, bile	

Procedure

1. Mark the test tubes 1 and 2.
2. Fill test tube # 1 ½ full with water.
3. Fill test tube # 2 ½ full of bile.
4. Add several drops of oil to both test tubes.
5. Shake test tube # 1. Describe what you saw.
6. Shake test tube # 2. What did you observe.
7. What nutrient is found in oil?

5. ____________________
____

6. ____________________
____

7. ____________________
____

Questions

1. In what ways is the powdering of the sugar cube (done in a previous lesson) similar to the emulsification of oil?
2. What does each process do to the amount of surface that can be acted upon?
3. In what way is the action of bile on fat the same as the action of soap on fat?

8. HOW CAN WE SHOW AN ARTIFICIAL SMALL INTESTINE?

Outcomes

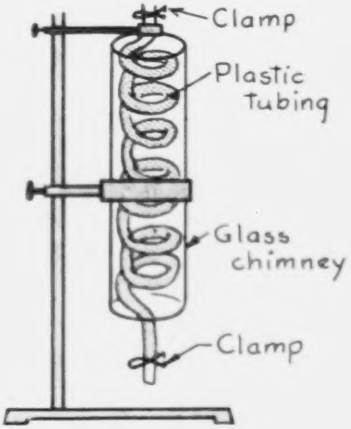
- Food in the digestive tube is not yet part of the body.
- Foods must be changed before they can be used by the cells of the body.
- Foods must be made simpler (broken down) and changed (made soluble) in such a way that the nutrients can pass through the walls of the small intestine.
- *The inside wall of the small intestine is lined with a membrane that allows only certain molecules to pass through.*

Motivation

How is it possible to starve to death even though the food tube is filled with food? Elicit that to do any good, food must leave the food tube and reach the rest of the body.

Development

1. Use a Graham condenser, or, coil about 2 feet of clear plastic tubing inside a glass chimney as shown:



Ask pupils "How can 20 feet of small intestine fit inside our bodies, which are so much shorter?"

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2. Fill plastic tubing with colored water. Tell pupils this is a "model" of the digestive system in an animal's body. The colored water represents the food in the digestive tract. The clear glass chimney represents the body.

3. Indicate where the mouth and rectum would be in the model of the animal.

4. Have pupils refer to the mannikin and charts of the human digestive tract to see the analogy between the plastic tubing in the demonstration and the human small intestine.

5. Have pupils note that the food (colored water) in the plastic tubing is separated from the rest of the body.

6. Referring to the motivation, elicit what must happen in order for the "food" in the tubing (or small intestine) to get into the body.

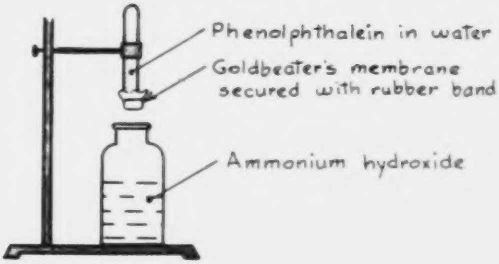
7. To show that some molecules can pass through a *membrane* (or wall), demonstrate the following:

   To a test tube of water, add a few drops of a 1% solution of phenolphthalein in alcohol. Cover the mouth of the test tube with a wet goldbeater's membrane, and fasten with a rubber band.

7a. *Discuss the terms diffusion, permeability, and semi-permeability.*

   Ask why the water molecules were not able to go out of test tube, but the ammonium molecules were able to go in.

a. *Briefly discuss how chemical indicators are used.*



Invert test tube over open mouth of a bottle of ammonium hydroxide. Phenolphthalein turns red when molecules of a base such as ammonia are added. Ask, "Why did the color change?"

Summary

1. In order to do us any good, what must be done to food that we eat?
2. In the model of the digestive system, what did the plastic tubing represent? the colored water? the clear glass?
3. If the food inside the intestine could not get through the wall, what would happen to the cells of our body?
4. *What causes the molecules of perfume in an open bottle to eventually spread throughout the entire room?*
5. *What other "indicators" have you used before in science?*

Homework

1. What changes has the food undergone on its way to the small intestine?
2. Why is the small intestine coiled up inside our body?
3. *Why doesn't food in our intestines flow back into our stomach when we bend over?*

Materials

2′ length of clear plastic tubing
Ring stand, clamps
Graham condenser
Ammonium hydroxide
Phenolphthalein
Test tube
Rubber band
Tape
String
Beaker
Marking pencil
Bottles of food mixtures

NOTE: Three to four days in advance of Lesson 11, prepare:

Goldbeater's membrane
2% glucose and sodium chloride solution
2 beakers of water
Starch suspension
Gelatin
String
Tape

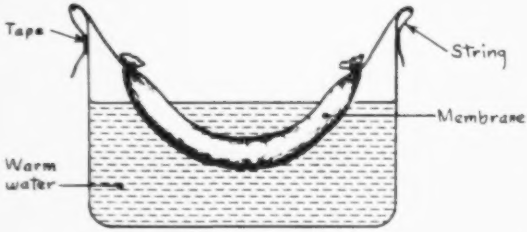
Show pupils what you are doing.

a. Make a mixture of 2% solution of glucose and sodium chloride, starch suspension, and egg white. Label the mixture *U*.

b. The second mixture is the same with *pepsin added*. Label it *D*.

c. Use two 8" strips of goldbeater's membrane, one to be filled with mixture *U*, the second with *D*. Tie the ends. Suspend each membrane in a beaker of water and label beakers *U* and *D*.

d. Do not change water in the beakers. These setups are to be used, as is, in Lesson 11.



9. WHICH NUTRIENTS ARE FOUND IN THE INTESTINE?

Outcomes

- We cannot identify nutrients by observation alone.
- Digestion of food begins in the mouth and continues until it is ready to leave the small intestine.
- Different nutrients begin to be digested in different parts of the digestive tract.

Motivation

Show the pupils two beakers, one beaker ½ filled with sweetened water, and the other beaker ½ filled with distilled or tap water.

Ask pupils what the beakers contain. Elicit why they are unable to tell what is in the beakers by only observing them.

Development

1. Have pupils examine the bottle of intestinal food mixture prepared the previous day.

   Ask pupils how we may identify what nutrients are in the artificial intestine constructed in the previous lesson.

2. Review the tests for sugar, starch, protein and salt. Lead pupils to the understanding that by going through these tests with the "unknown" in the intestine, we are able to identify the nutrients.

2a. Discuss with pupils how chemists are able to determine which chemicals are present and their quantitative amounts, in an unknown mixture. Refer to testing blood or urine for sugar.

3. Set up the tests for sugar, starch, protein, and salt.
   a. To four (4) test tubes add an equal amount of the food mixture. Label them #1-Sugar; #2-Starch; #3-Protein; #4-Salt.
   b. To the tube #1, add 5 cc of Benedict's solution. Heat over burner gently until there is a color change. Have pupils observe and record.
   c. To the tube #2, add a few drops of Lugol's solution. Ask: "Is starch present?" Pupils should record their observations.
   d. To the tube #3, add a few drops of fresh Biuret solution. Note change if any. For what nutrient does this solution give a positive test? Pupils should record the results.
   e. To the tube #4 add about 15 drops of silver nitrate to the mixture. Have pupils observe the formation of a white solid.

      Elicit which nutrients have a white, or ash-color material.
   f. Ask pupils what has happened. Discuss briefly the chemical reaction and the formation of Ag Cl as a precipitate.

$$AgNO_3 + NaCl \rightarrow NaNo_3 + AgCl\downarrow$$

Discuss with pupils the importance of silver compounds in photography.

4. Elicit from pupils the results of each of the four tests demonstrated. What nutrients were present in the food mixture?

5. Ask pupils, "What method can we use to determine what is in an "unknown" food mixture?"

6. Challenge pupils as to where each of the above nutrients begins to be digested in the digestive tract.

7. Elicit from pupils why there would be still present in the small intestine, sugar, starch, proteins, and salts. Guide them to conclude that digestion of all the nutrients is completed in the small intestine.

Summary

1. If not by observation, how are we able to identify the different nutrients in a mixture?

2. Is each test specific for a particular nutrient? Give an example.

3. Does test tube #3 contain sugar? Explain.

Homework

1. Which of the nutrients tested need to be digested? Why?

2. Where is the digestive process completed?

3. What food in your home contains all of the four nutrients (sugar, starch, protein and salts) combined?

4. *What is a precipitate?*

5. *Explain how silver compounds are used in photography.*

Materials

4 test tubes
Test tube rack
Food mixture
Benedict's solution
Lugol's solution
Biuret solution
Silver nitrate compound
Two (100) milliliter beakers
Distilled or tap water
Sweetened water

10. *WHAT ENZYME HELPS OUR STOMACH TO DIGEST MILK?

LABORATORY LESSON

Outcomes

- Rennin is one of the enzymes produced by the glands in the stomach walls.

- Rennin coagulates the protein in milk and aids the digestion of milk.

- Heat destroys the ability of this enzyme to do its work.

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* Only for classes programmed for five periods

Motivation

Ask, "Is it true that milk turns 'sour' in your stomach?"

Development

1. Have pupils recall that pepsin (with hydrochloric acid) was an enzyme that acted upon the protein in meat.
2. Point out that other enzymes are also produced in glands located in the wall of the stomach.
3. They will see how another enzyme, rennin, found in the stomach, acts upon milk.
4. They will also investigate the effect of heat upon the action of this enzyme.
5. They are going to use Junket which contains the enzyme rennin.
6. Distribute Worksheets and materials. Guide them through the laboratory procedures.

Homework

1. Name 2 foods other than milk, which contain the same kind of protein that is found in milk.
2. Why do you think this is so?
3. Is the following statement true or false? Explain, "The size of the protein molecule is smaller after rennin has acted on it."

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 10

Problem: What effect does rennin have on milk?

Materials

Powdered junket
Three test tubes
Test tube rack
Alcohol burner
Milk
Test tube holder
Marking pencil
Lugol's solution
Benedict's solution
Biuret solution
Filter paper
Funnel

Procedures

1. Add about an inch of milk to each of three test tubes numbered 1, 2, and 3.
2. Add about ⅓ inch of Junket powder to test tube #1 and #3.
3. Warm test tube #1 and #2. Do not boil.
4. What did you see happen to test tube #1? ______________________

   Why did this not happen in test tube #2? ______________________
5. Boil test tube #3 carefully for a few minutes. What did you observe?

   ____

   Compare this result to that observed in test tube #1. What do you think caused this difference? ______________________________
6. Filter the mixture from test tube #1, using the filter paper and a funnel.

   Place the material remaining on the filter paper into a test tube and add about 2 inches of water.
7. Add Biuret solution to the solution in the test tube.

   What do you observe? ______________________________

   Which nutrient is present? ____________________________

   Which nutrient does rennin act upon? ______________________

Summary

1. What nutrient did the test show was present? How did you find out?
2. What does rennin do?
3. What effect did boiling the milk have on the action of the rennin?

11. WHY MUST NUTRIENTS BE DIGESTED?

LABORATORY LESSON

Outcomes

- Some materials — sugar, digested protein, gelatin, and salt — are able to pass through the membrane of the artificial intestine.

- Starch and undigested protein do not pass through the membrane, therefore they need to be digested so that they can pass through the wall of the small intestine and into the bloodstream.
- Some nutrients, such as dissolved salts, minerals, and water do not have to be digested, since they can pass through the membrane.

Motivation

Show pupils some coarse salt in a test tube. Ask them how it would be possible to make the salt pass through some filter paper.

Recall their work in chemistry where it was demonstrated that dissolved salts in solution will pass easily through filter paper.

Development

1. Have the pupils recall from Lesson 8 that, to be useful, the nutrients must reach the body cells. They must, therefore, be able to pass through the wall of the digestive or food tube. This takes place in the small intestine.
2. Show pupils the artificial intestines filled with the food mixtures, placed in beakers of water, that were prepared in Lesson 8.

   Ask them how we can determine which nutrients were able to pass through the membrane.
3. Lead them to realize that any material which has passed through the membrane would be present in the water.
4. Distribute Worksheets and materials. To one-half of the class give samples of water from beaker with the membrane containing the undigested protein (beaker U). To the other half, give the samples of water that were in the beaker with the membrane containing digested protein (beaker D).
5. After the pupils have completed their activities, lead them to conclude that sugar and salt were found in the water of both samples. Only those with water from the second beaker (D) (digested protein) showed the presence of protein.
6. Have the pupils understand that only digested foods can pass through he membrane.

7. **Lead the pupils to the understanding that the intestine must have tiny spaces which only digested food can fit through.**

Homework

1. Why is digestion necessary in a living thing?
2. Which nutrients can pass out of the intestine?
3. Explain why enzymes are necessary for life.

Materials

Test tube
Coarse salt
Filter paper
Beaker

For additional materials see NOTE at end of Lesson 8.

Enrichment

1. *Compare the size and functions of the stomach to the size and function of the small intestine.*
2. *How can our emotions affect our digestion?*
3. *What is our appendix? Where is it found? Does it serve any purpose in man? In other animals?*
4. *What would be the effect upon digestion if several feet of intestine were removed?*

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 11

Problem: Which nutrients pass through the walls of the small intestine?

Materials

Test tube rack with 4 test tubes
Test tube holder
Alcohol burner
Marking pencil
Samples of food mixtures
1" piece of dialyzing (goldbeaters) membrane

Bottle of each:
- Lugol's solution
- Benedict's solution
- Biuret A
- Biuret B
- Silver nitrate

Procedure

1. Number test tubes 1, 2, 3, 4.
2. Place about ½" of liquid, which surrounded the artificial intestine, into each test tube.
3. Put a few drops of Lugol's solution into test tube #1. What did you observe? ______________________________
4. Put about 15 drops of Biuret A and 5 drops of Biuret B into test tube #2. What did you observe? ______________________________
5. Put about 10 drops of silver nitrate into test tube #3. What did you observe? ______________________________
6. Place one inch of Benedict's solution into test tube #4.
7. Using test tube holder, hold test tube #4 over the alcohol burner flame. Heat gently until no further color change takes place. Replace test tube in rack. (CAUTION: DO NOT TOUCH TEST TUBE WITH YOUR FINGERS. IT IS HOT.) What did you observe? ______________________________

Summary

Record your observations in the table

NUTRIENTS	FOUND IN LIQUID OF BEAKER U?	FOUND IN LIQUID OF BEAKER D?	NEEDS DIGESTION	DOES NOT NEED DIGESTION
Glucose (sugar)				
Sodium chloride (salt)				
Starch				
Protein				

1. Which nutrients were found in both samples of water?
2. Which nutrients were not found in the water from beaker U?
3. Why was the nutrient protein found only in sample from beaker D?
4. What could we have added to the food mixture in beaker U so that starch might be changed to sugar to enable it to pass through the walls of the intestine? ______________________________

12. HOW DO DIGESTED FOODS GET INTO THE BLOOD?

Outcomes

- Digested food and other dissolved materials pass through the wall membrane of the small intestine into blood vessels, which absorb food.
- Only molecules are small enough to pass through the wall of the small intestine.
- *The chief methods of distributing food are by diffusion and active transport.*
- The lining of the small intestine is covered with small projections (bumps) called villi. The villi increase the surface area of the small intestine, thereby allowing more food to be absorbed into the blood.

Motivation

Show a small piece of screen wire. On one side place some marbles, on the other side some sand. Ask which will pass through the screen. Why?

Development

1. Show a model, and/or a chart of a cross-section of the small intestine. Point out the "bumps", or projections on the surface of the lining as *villi* (plural) or villus (singular). Compare the villi to trees on a ridge, or the wire needles on a scouring brush.

2. Point out on the chart that the intestine is completely lined with a thin membrane. Locate and identify the villi under the membrane.

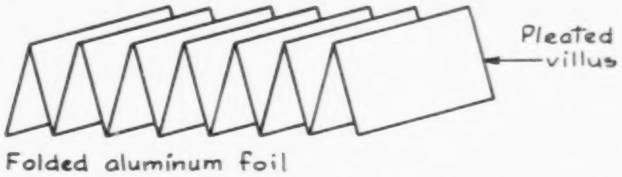
2a. Refer back to the dialyzing tubing used as an artificial small intestine, which is a form of semi-permeable membrane.

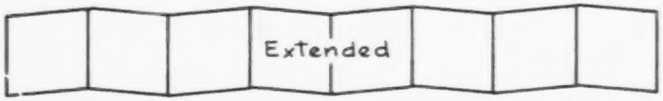
3. Using a model of a villus, show the pupils that blood vessels pass into every villus, directly under the membrane.

4. Demonstrate how the villi of the small intestine increase the *absorption* (passing through) process by increasing the surface area.

   a. Fold a large piece of aluminum foil as for a paper fan, or an accordion.

b. Have pupils compare the surface areas.





4a. *Discuss active transport in terms of how the digested material (dissolved) passes through the membrane.*

5. (Optional) Show a simple model of a single villus.
   a. Fray the ends of a many stranded rope, cut to the length of the test tube.
   b. Separate the strands in the middle of the rope.
   c. Attach the frayed ends with tape to the outside of the test tube.
   d. Push the separated strands up into the test tube with a pencil.

6. Ask the pupils to explain how the food they ate last night is able to become a part of their blood today.

6a. *Ask pupils to explain how soluble foods get into the blood stream by the process of diffusion (from area of higher concentration to lower concentration).*

Have them compare diffusion and filtration.

Develop the role of the villi in active transport which permits digested food to enter the blood stream even when the concentration in the blood is greater.

Ask if diffusion takes place anywhere else in the body (i.e., respiration).

Summary

1. Why could the sand pass through the screen wire, whereas the marbles could not pass?

2. What must happen to most of the foods we eat before they can be used by the body?
3. How is the small intestine especially adapted for this purpose?
4. When our food is digested properly, what happens to it?

Homework

1. What is a villus?
2. Why is the surface of the small intestine covered with villi, instead of being smooth?
3. How can food get through the membrane of the small intestine?
4. What items do you have in your home that will allow some things to pass through them and will not allow others to pass?
5. Draw and label a single villus, showing membrane and blood vessels.

5a. Why is the food able to pass into the bloodstream, but the blood (also a liquid) does not pass into the small intestine?

Materials

Aluminum foil
Scissors
Rope
Test tube
Scotch tape
Red and blue ink
Wire screen mesh
Marbles
Sand

CIRCULATION AND RESPIRATION

Suggested Lessons and Procedures

13. HOW DOES BLOOD CIRCULATE?

Outcomes

- The blood flows in most animals in a closed system of blood vessels.
- The blood vessels include arteries, capillaries, and veins. Arteries carry blood away from the heart. Veins carry blood to the heart. Capillaries, a network of tiny tubes, connect arteries and veins.
- Other living organisms, plants and animals, also have a system of circulation.

Motivation

We have learned that food is digested in the digestive system. Since the cells need the food, how does the food get to the cells?

Development

1. Set up a bioscope and demonstrate the circulation of the chloroplasts in the Elodea. Make a slide (wet mount) of the top leaves of the Elodea plant. Warming the slide increases movement.
2. Have pupils note the moving chloroplasts. Ask, "What is the value of this movement?"

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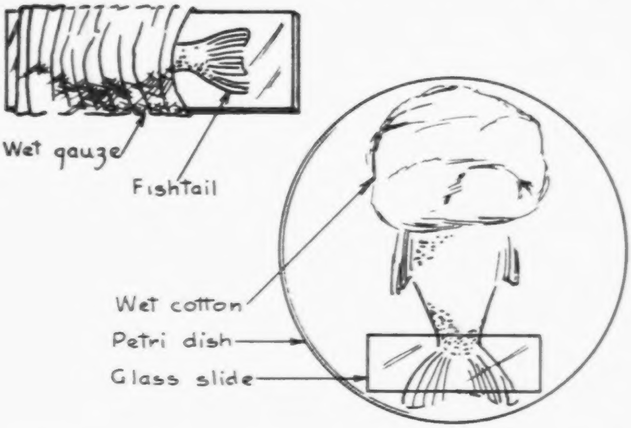
2a. Discuss the function of chloroplasts and what causes their movement.

3. Prepare the goldfish for viewing under the bioscope.

3a. Place a tubifex or Daphnia on a depression slide. Add a cover slip. Examine under low power. Observe the faint pulsating "heart".

   a. Wrap the body of the fish in wet absorbent cotton so that only the tail is exposed. Place it in a Petri dish with a small amount of water. Cover the tail with a slide to hold it flat and expanded.

   b. Or place the fish on a slide. Wrap it to the slide with wet gauze.



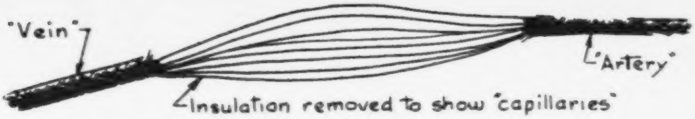
4. Point out the flow of blood in the *arteries* in one direction and in the *veins* in the other direction (capillaries may not be visible).

   Have pupils contrast the flow of blood in the arteries (blood flowing away from heart) to the blood flow in the veins (toward the heart).

   Have pupils observe (if visible) the criss-crossing network of *capillaries.*

   Ask "Where does the blood flow most rapidly?"

5. If time permits, show a model of the blood vessels by removing the insulation from the center section of a 4" length of copper wire. Separate and spread apart the individual strands of wire. These can represent the capillaries as shown:



5a. Examine the celery stalks (and leaves) which have been put into dyed water. Cut across the stem. What do you observe?

Summary

1. Is the circulatory system a tube open at both ends, as is the digestive tract? Explain.

1a. Compare the circulation in the Daphnia to that in the fish.

2. What are the 3 types of blood vessels in our body?

3. Trace the direction of the flow of blood through these vessels.

4. What evidence of circulation is there in the stem of the celery?

Homework

1. What is meant by a closed circulatory system?

2. Describe the way the steam-heating system operates. Why can it be called a closed system?

3. How does the flow of blood in the arteries differ from the flow in the veins?

4. Compare the advantages of a closed system over an open circulatory system.

5. When we cut our finger which blood vessels are broken? How do you know?

6. Why does our face turn red when we blush?

Materials

Bioscope
Goldfish
Petri dish
Glass slide
Absorbent cotton
Stalk of celery
Beaker of dyed water
Elodea leaves
Daphnia or tubifex

14. HOW DOES OUR HEART MAKE THE BLOOD CIRCULATE?

Outcomes

- The heart is a muscular organ, which pumps the blood through the body.
- The heart is divided into 4 parts or chambers. The two upper parts, the left and right atriums, receive blood. The two lower parts, the left and right ventricles, pump the blood out of the heart.
- The pulse indicates the heartbeat.
- *Valves in the heart keep the blood from flowing backwards.*
- *The walls of the arteries are thicker and stronger than the walls of the veins.*

Motivation

Display a beef heart (obtainable from a local butcher). Ask, "How is the heart built so that it can perform its job?"

Development

1. Dissect the heart. Together with a model and a chart of the human heart and circulatory system, locate the internal structures.
2. Ask "How many parts or chambers are found in the heart?"
3. Ask "How do the upper two chambers (the left and right *atriums* which receive blood) compare in size and wall thickness with the lower two chambers (the left and right *ventricles,* which pump blood out of the heart)?
4. Guide pupils in concluding possible reasons for this difference.
5. Have them observe the veins entering the heart, and the arteries leaving the heart.

5a. Compare the thickness of the walls in the arteries and in the veins. "Is there a difference?"

b. What is arteriosclerosis?

6. Lead the pupils to understand that the blood flows through the

arteries to all parts of the body, and returns through veins that enter the right atrium.

7. Elicit the effect on the blood in the heart when the ventricles contract.

8. By means of the charts and model help the pupils trace the flow of blood through the heart:

   Blood enters the right ventricle from the right atrium.

   The right ventricle then contracts forcing the blood into vessels leading to the lungs. Ask, "Why is blood made to flow into the lungs?"

   From the lungs, blood enters the left atrium.

   When the atrium contracts blood enters the left ventricle.

   The left ventricle then contracts. Ask "Where does the blood go after being pumped out by the left ventricle?"

8a. Discuss the role and structure of the valves in the heart.

b. Discuss heart murmurs.

9. Ask pupils "In what way are the ventricles constructed so that they are suited for the job they have to do?"

10. Referring to the charts, help the pupils locate their hearts.

11. Elicit from the class that each time the ventricles contract, blood spurts through the arteries.

12. Ask if it is possible to feel this spurting.

13. Help pupils locate their *pulse* by instructing them to place their index and middle fingers of one hand on the inner side of the other wrist, about 1½ inches above the wrist joint.

13a. Elicit the role of "pressure points" in first aid.

Summary

1. Make a labelled diagram of the internal structure of the heart.

2. Starting from the right atrium, list in proper order, the parts of the heart through which blood flows.

3. What would happen if the valves in the heart were damaged?

Homework

1. Rearrange the following in the order that blood flows through them; veins, capillaries, left ventricle, right ventricle, lungs, arteries, left atrium, right atrium.
2. Compare the atriums and the ventricles from the standpoint of their function and structure.
3. *Describe the causes of some diseases of the heart and the circulatory system.*

Enrichment

For further research and study pupils may report on such topics as:

1. *The comparative structure and functions of the heart in the earthworm, fish, frog, and man.*
2. *Open-heart surgery; heart massage; "elevated" blood pressure.*
3. *Instruments used by doctors, such as stethoscope and sphygmomanometer.*

15. *WHAT DOES OUR PULSE TELL US ABOUT OUR HEART?

LABORATORY LESSON

Outcomes

- The pulse is the result of the squeezing of the blood, in spurts, through the arteries by the heart.
- A stethoscope allows us to "hear our heartbeat".
- The pulse rate usually differs from one person to another, from boys to girls, and depends upon how active our body is.

Motivation

When someone is lying unconscious after an accident, why does the doctor usually place his ear near the person's chest? Elicit that he is listening for the heartbeat.

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* Only for classes programmed for five periods

Development

1. Display a *stethoscope*. Elicit its purpose. Tell pupils they are going to use a stethoscope to listen to their heartbeat.

2. Demonstrate how to use the stethoscope.

   NOTE: If necessary, a simple stethoscope may be made, using a funnel and rubber tubing.

3. Demonstrate the pulse, using a rubber bulb filled with water, and connected to about 2 feet of soft rubber tubing. By alternately squeezing and relaxing the rubber bulb, a pulsating flow can be produced in the tubing and observed by the students.

4. Relate this to the similar actions of the heart, which causes blood to flow into the arteries in "spurts" or "pulses". We can feel these "spurts" in an artery when the artery lies close to the surface of our body, such as in our wrist.

5. Distribute Laboratory Worksheets and materials. Guide the pupils in reading and following instructions.

   NOTE: DO NOT PERMIT "LIMITED PHYSICAL ACTIVITY" PUPILS TO DO THE EXERCISES.

6. After the laboratory work is completed, including the summary, prepare a chart on the chalkboard, placing on it a sample of data from the Worksheet. Elicit from the pupils that:

   a. There is no one "right" or normal pulse rate for everyone.

   b. There is a difference between boys' and girls' pulse rates.

Homework

1. At home, compare the pulse rate of your father or mother with your brother, sister, or yourself.

2. When does your heart beat faster, before or after exercise?

3. What does a faster beating heart do to the rate of flow of blood in your body? Why is this helpful?

Materials

Stopwatch or watch with sweep-second hand
Home baster or rubber bulb attached to thin rubber tubing
Stethoscope (S-1, or school-made type)

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 15

Problem: What do our heartbeat and pulse tell us?

Materials

Stethoscope Pencil and paper

Procedure

1. Use the stethoscope to find the heartbeat:
    a. Place the earpieces of stethoscope properly in your ears.
    b. Place the stethoscope over the heart area (slightly left of the center of your chest between the fourth and fifth ribs). Very slowly move the stethoscope until you hear the loudest sound.
    c. Count the number of heartbeats you hear in one minute. Your teacher will tell you when to start and stop.
    d. Have each person in your group try to use the stethoscope. Record your findings below, in the heartbeat column.

HEARTBEAT		PULSE RATE (BEFORE EXERCISE)	PULSE RATE (AFTER EXERCISE)
1st person	beats		
2nd person	beats		
3rd person	beats		
Others	beats		
Your group's average	beats		

e. Describe the sound you hear.________________

2. Each person will take his own pulse for 1 minute. The teacher will tell you when to start and stop.
    a. Record your pulse rate on the chart above (before exercise), next to your heartbeat.
    b. Compare your heartbeat with the pulse rate. Is it similar?____________
    What does this tell you? ______________________________

3. Upon instruction from your teacher, two members of your group will hop in place 25 times, and then sit down. Take your pulse and record it on the chart above (after exercise).

   Note: If you are restricted from gym activity, you are *not* to do this exercise.

4. Compare this rate with the pulse rate before exercise. It is (the same, higher, lower) ____________________.

Summary

1. What is the connection between heartbeat and pulse rate? ____________
____
2. Did all of the people in your group have the same heartbeat? The same pulse rate? Explain. ____________________________
____
3. What does it mean when there is a change in the pulse rate after exercise?
____

16. HOW CAN WE FIND OUT WHAT IS IN THE BLOOD?

Outcomes

- Various tests can be used to determine the blood's composition.
- The solid and liquid parts may be separated by centrifugation.
- Blood particles and clotting of blood may be studied under the microscope.
- *Clotting of blood is aided by other substances in the blood.*

Motivation

Show sample of blood in a test tube and ask: "Why is blood called the *river of life?*"

Development

1. Have pupils recall the methods they used in the food mixtures. Elicit how they separated mixtures in chemistry.

   Ask "What must be done to determine what is in blood?" List these suggestions on the chalkboard.

2. Ask pupils how the solid parts in a mixture may be separated from the liquid. Have pupils recall how the *centrifuge* was used.

   Demonstrate the separation of old blood with the centrifuge.

   Show the pupils that the solid part of the blood settles to the bottom and the liquid is on the top. Elicit why this happens. Establish the percent of solid to liquid parts of the blood (approximately 50%).

3. Set up and project a drop of human blood on a slide under the bioscope. Point out the process of coagulation *(clotting)*. Have pupils note the time it takes for a clot to form. Ask pupils "When is it useful for blood to clot?"

3a. What parts of the blood aid in blood clotting? Which of the two main parts of blood have the sole function of clotting? Introduce clotting factors. What is the cause of hemophilia?

4. Elicit the chemical tests which can be used to determine the presence of nutrients in the liquid part of the blood.

5. If time permits, demonstrate how blood slides are prepared; otherwise, do this in the preparation room. These slides will be used in the next lesson.

5a. You may wish to demonstrate how a blood drop is obtained in a hospital. Pupils may not be used in this activity.

Take a drop of blood from your *fingertip, using a disposable lancet (S-1 12-5068). Mount it and allow it to dry in the air. To the dried blood, add a crystal of salt, a drop of water, and finally a drop of glacial acetic acid. Apply a cover slip. Gently heat one end of slide until bubbles escape. Under the high power, locate the reddish-brown rhombic crystals of hemin.*

Using outdated human blood, or blood from frozen liver, follow these steps:

a. Put a drop of blood on one slide and spread by placing another slide over slide #1, holding it at a 45° angle.
b. Pull slide #2 over until it touches the drop of blood on slide #1. The blood will spread between the slides.
c. Push slide #2 quickly toward the other end of slide #1.
d. Lay slide #1 across the top of a beaker.
e. Cover the blood with Wright's stain. Let stand one minute.

f. Now put the same amount of water on the slide. Allow the water to stay on the slide for three minutes.

g. Holding the slide between your thumb and forefinger, squirt water on the slide with a dropper until water runs off clear.

h. Let the slide drain. Place across the beaker and allow to dry.

i. Do not wipe the slide.

j. Label the slide.

k. Retain for viewing under a microscope or bioscope.

Summary

1. Blood is a mixture. What are several ways we can tell what is in a mixture?
2. Why does the doctor take a sample of your blood?
3. What does the blood contain?
4. What happens to normal blood on exposure to air? Is this good or bad? Explain.
5. What is the best way to study the parts of the blood?

Homework

1. What is meant by "blood performs a messenger service."
2. How can we learn what is in the blood? Name the different methods and what you may expect to find with each method.
3. Why is it important for blood to be able to clot?
4. *Explain briefly what is meant by thrombosis, embolism, hemophilia.*
5. *What does a blood test tell the doctor?*

Materials

Bioscope
Microscope slides
Blood (outdated)
Beaker
Wright's stain

Droppers
Charts of blood cells
and other parts of blood
Centrifuge

17. WHAT IS THE COMPOSITION OF BLOOD?

LABORATORY LESSON

Outcomes

- Blood is a mixture of cells and chemicals in water.
- Digested food and carbon dioxide are carried by the liquid portion (plasma) of the blood.
- Red blood cells carry oxygen.
- White blood cells destroy germs that enter the body.
- The blood cells of different animals vary in size, shape, structure, and color.

Motivation

Have pupils recall the procedure followed by teacher in preparing slides in the previous lesson. Ask, "What part of the blood remained on the slide?"

Development

1. Elicit from pupils that blood is mainly water, with solid substances known as white and red blood cells, and platelets; dissolved digested food, gases and chemicals. Introduce the term *plasma* as the name of the liquid part of the blood. Ask, "What part of the blood is frequently sent overseas for service men?"
2. Discuss briefly the functions of the different parts of blood. The *red blood cells* carry oxygen (by means of *hemoglobin,* which gives the blood its red color). Recall the function of *platelets.* Relate that the white blood cells can pass through the walls of the capillaries to fight disease germs.
3. Tell pupils that they are going to study the "solid" parts of the blood under the microscope. The solid part is approximately 45% of the blood.
4. Distribute Worksheets and guide pupils in the procedures.

Homework

1. What accounts for the red color of blood?

2. What gas is carried by the red blood cells?
3. What makes up the greatest percentage of blood?
4. Look up the meaning of the word *anemia*. What may be the cause of anemia, and how can it be corrected?

Enrichment

1. *Report on the disease* sickle-cell anemia.
2. *Discuss the importance of blood counts, and the amount of hemoglobin in blood.*
3. *What is the importance of blood banks?*
4. *Report on: transfusions, blood storage.*

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 17

Problem: What do the "solid" parts of blood look like?

Materials

Microscopes
Paper
Charts of blood cells and plasma
Pencils
Slides of prepared human blood cells
Slides of frog's blood

Procedure

1. Set up your microscope according to your teacher's instructions.
2. Place the previously prepared slide of blood on the stage of the microscope and clip it in place.
3. Focus the slide using the low power objective.
4. Make a drawing of what you see.
5. Now, turn the high power objective into viewing position.
6. Focus again.
7. Draw what you see. Label each part.
8. Repeat the above steps (1 to 7), using a prepared slide of frog's blood.
9. Draw what you see. Label.
10. Compare your drawings with charts of the different parts of blood.

Summary

1. What part of the blood did we wash off in preparing our slides? ______
2. What is the above part of blood composed of? ______
3. Name the particles you saw when you used the microscope. ______
4. What differences did you notice in size, shape, parts of the cells, and color? ______
5. Compare the slides of the human and frog blood. ______
6. What is the job of *each* of the following: red blood cells, white blood cells, and plasma? ______
7. What did you see under high power that you did not see under low power? ______

18. HOW DOES THE OXYGEN IN THE AIR GET INTO THE BLOOD?

Outcomes

- The lungs, major organs of the respiratory system, are concerned with exchanging the gases O_2 and CO_2.
- The circulatory system and the respiratory system work together in taking in oxygen, its distribution to the cells, and in the elimination of carbon dioxide.
- *Exchange of gases in the air sacs is mainly by diffusion.*

Motivation

Show pupils the lungs of a sheep or cow (obtain from a local butcher). Drop them into a large battery jar of water, and ask why they float.

Development

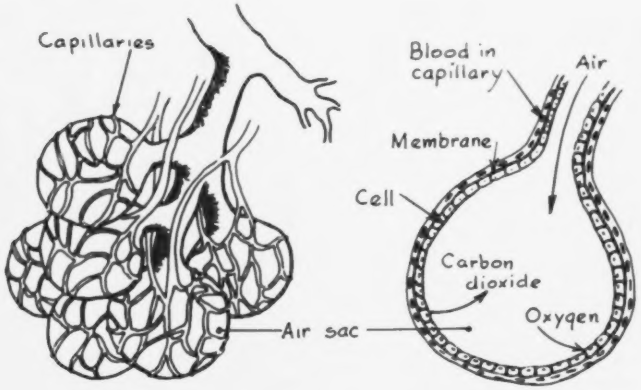
1. Have some pupils come up and feel the lungs. Elicit the fact that the lungs have a spongy feeling.

2. Lead the pupils to the understanding that the lung contains a great deal of air. Have the pupils recall that in breathing we inhale air (containing oxygen) and exhale CO_2.

3. With the aid of charts of the human lung, demonstrate the single air tube branching and dividing many times, resulting in smaller and narrower tubes. Have the pupils understand that the ends of these tiny tubes balloon out to form tiny thin-walled *air sacs.*

4. Refer to the diagram. Have the pupils reach the conclusion that only a thin membrane separates the blood in the capillaries from the oxygen in the air sacs.

4a. Elicit the results on the body of damage or destruction to these air sacs (i.e., smoking).

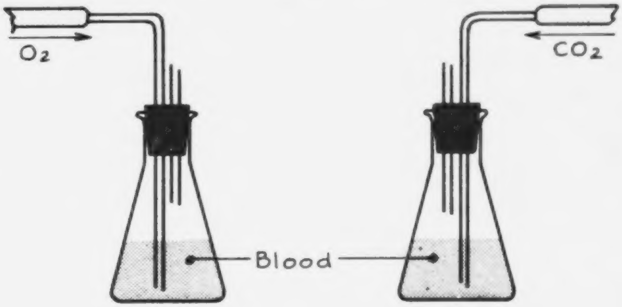


5. Ask pupils to recall the digestive process, and why digestion was necessary. Relate this to the fact that only particles of molecular size can pass through the membrane. Lead pupils to conclude that the air sac membrane permits molecules of oxygen to pass into the blood, and the molecules of carbon dioxide can get out of the blood.

5a. Discuss diffusion as the means by which gases are exchanged in the lungs.

6. Ask the pupils to recall the function of red blood cells. Lead pupils to understand that oxygen is transferred from the air sacs and combines with the hemoglobin in the red blood cells.

7. Ask, "What is the color of blood?" Demonstrate the effects of oxygen and carbon dioxide on blood samples, as follows: Using tanks or gas generators, bubble oxygen and carbon dioxide through the blood as shown in the diagram.



NOTE: a. Outdated blood may be obtained from the nearest hospital. Fresh blood may be obtained from a slaughter house.

b. When using tanks of gas, open valve slowly and carefully to avoid too high a pressure.

8. Ask, "What changes did you notice in the color of the blood?" "What caused these changes?"

9. Ask pupils "Why do you think red and blue colors are used in the charts of the circulatory system?"

   Guide the pupils to conclude that veins carry blood containing carbon dioxide to the heart, which in turn send it to the lungs. Here the carbon dioxide is released and oxygen is picked up. Is blood in the veins really blue?

10. Review the use of oxygen and the production of carbon dioxide in the cells (7th grade Biology unit).

10a. Discuss carbon monoxide, its production by incomplete combustion, and its effect on the body.

Summary

1. In what part of the lung does an exchange of gases take place?
2. Describe the air sac.

3. Why is the air sac surrounded by capillaries?
4. Describe the difference in color and content between oxygenated and deoxygenated blood. In what blood vessels are each found?
5. *Why does the carbon dioxide leave the blood in the air sac?*

Homework

1. Describe what takes place in the air sacs.
2. In what three ways does oxygenated blood differ from deoxygenated blood?
3. Where does blood go after it leaves the lungs?
4. *Name two ways in which the lungs may be damaged.*
5. *What would happen if there were a hole between the two ventricles in the heart?*

Materials

Tanks of carbon dioxide and oxygen
Two flat-bottomed Florence flasks (500 ml)
Rubber tubing
Two 2-hole rubber stoppers
Glass tubing
Outdated blood, or fresh animal blood
Small bottle of perfume
Charts of human respiratory system and circulatory system

19. HOW DO THE PARTS OF THE RESPIRATORY SYSTEM WORK TOGETHER TO GET AIR INTO OUR BODIES?

Outcomes

- The respiratory system is composed of many organs working together to supply the body with oxygen and to get rid of carbon dioxide and water vapor.
- *The respiratory tract is lined with a sticky mucus membrane and hair-like cilia.*
- The structure of the organ is determined by the work it does.

Motivation

Is it true that mouth breathers get more colds than nose breathers?

Development

1. Elicit that we normally breathe through our noses, and blocking prevents the air from coming through. The nose also warms, moistens, and sifts the air. This helps to prevent colds.

1a. Discuss the mucus and cilia in respiration. Elicit that air is filtered, cleared of dust, moistened and warmed before it may enter the lungs.

1b. Why do we sneeze?

2. Using a wall chart, the manikin, and the bell-jar model, discuss the structure and function of the respiratory system.

   Identify mouth and nasal cavity, trachea, lungs, and diaphragm. Demonstrate by means of the bell-jar model, how the ribs, diaphragm, and lungs work together to inhale and exhale.

3. Ask, "Why do we sometimes choke when eating or drinking? Have pupils understand that food has gone into the air tube instead of the esophagus. Show that the nasal passage leads into the mouth then into the respiratory tube.

3a. Review the function of the epiglottis in digestion.

3b. Develop the understanding that the cartilages of the larynx protect the vocal cords.

4. Elicit that the respiratory tube *(trachea)* continues into the tissue of the lungs. Ask, "How many lungs do we have?" Then, "What must happen to the trachea before it enters the lungs?"

   Discuss the further branching of the tube into smaller and smaller branches until they finally lead into the air sacs. Compare this to the form of a tree.

4a. Discuss the job of the rings of cartilage of the trachea.

4b. Identify the parts, as the pharyx, larynx, bronchi and bronchioles. Ask, "What is bronchitis?"

5. Show fresh calf or sheep lungs:

   a. Place the lungs into a large pan of water. Allow pupils to observe the porous nature of the lungs. Asking, "Why do you think the lungs are made of this kind of tissue?", elicit that the lungs have air spaces or sacs. (Compare to a sponge.)

   b. Try to inflate the lungs by inserting rubber tubing into the trachea and blowing into it while the lungs are under water.
   c. Place the lungs in the dissecting pan. Try to arrange them to look like the lungs on the chart.
   d. Locate and examine the windpipe (trachea). Have pupils observe how it enters the lungs.
   e. Cut open the windpipe. Show pupils how it is lined with cartilage to keep the windpipe open.
   f. Trace the trachea so that the pupils can see the branching of the bronchi into the bronchioles. Elicit the name for the end of the tubes (air sacs).

6. Elicit from pupils the overall function of breathing including exchange of gases in both inhalation and exhalation.

Summary

1. What are the parts of the respiratory system?
2. Why do the parts look and feel different?
3. How does air get into the lungs?
4. Where does air finally stop in the lungs?
5. Why is the lung so light and spongy?
6. How do carbon dioxide and water vapor get out of the lungs?
7. *What would happen if the trachea were only muscle tissue?*

Homework

1. Why will a piece of lung float in water?
2. Describe the tube that carries air to all parts of the respiratory system.
3. Why is it better to breathe through the nose than through the mouth?
4. Draw and label the parts of the respiratory system.

5. *Sometimes food may go down the wrong pipe. Explain what happens in such cases.*

6. *How do coughing and sneezing help us?*

Materials

Chart of respiratory system	Manikin
Bell-jar model of respiratory system	Dissecting pan
Large pan with water	Dissecting kit
Fresh calf, or sheep lungs (Haslet)	

20. *HOW DOES THE AIR WE BREATHE IN DIFFER FROM THE AIR WE BREATHE OUT?

LABORATORY LESSON

Outcome

- The air we inhale differs from the air we exhale in that it has more oxygen and less carbon dioxide.

Motivation

Show that carbon dioxide turns brom-thymol blue to a yellow color. Have two pupils come to the lab table to place clean straws, one each into two test tubes, one half filled with brom-thymol blue, the other half filled with limewater.

Have them gently and evenly exhale through the straws until a color change is noticed in each test tube.

Ask pupils to recall previous learnings about the use of limewater to test the presence of carbon dioxide.

Ask what change occurred in:

test tube with limewater
test tube with brom-thymol blue

"What do you think caused these changes?"

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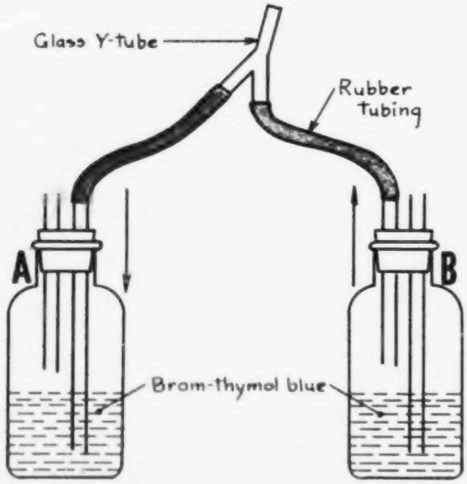
* Only for classes programmed for five periods

Display the apparatus as shown and ask pupils how this can be used to show if exhaled air is different from inhaled air.



Development

1. Attach a clean straw to the glass-Y tube shown in the device, and have another pupil inhale and exhale continuously without removing his lips from the straw.

2. Lead pupils to understand that air is inhaled through bottle B and exhaled through bottle A.

3. Ask pupils what change they think will take place in bottle A and why. Also ask what change should take place in bottle B and why.

   Note: To make this device, connect a glass Y-tube to two sections of rubber tubing. Fit one short and one long piece of glass tubing into each of two 2-hole rubber stoppers which fit two flasks or collecting bottles. Attach the rubber tubing to the short section of glass tubing in one bottle and to the longer piece in the other bottle. Pour about 100 ml of water into each bottle and add enough alkaline brom-thymol blue so that the water is colored light blue. Notice that only one tube, to which the rubber tubing is attached, extends below the level of the fluid in each bottle.

4. Tell pupils they will now perform some tests to see what changes take place in the oxygen and carbon dioxide content of the air when they exhale and inhale.

5. Distribute Worksheets and materials. Caution the pupils to be especially careful of the burning candle, keeping their sleeves, ties, and hair out of reach of the flame. Explain how to secure the candle to the glass plate by placing the bottom of the candle in a few drops of melted wax.

Homework

1. Besides giving off heat and smoke, what does a big fire do to the air around it?

2. Why will a candle continue to burn in a jar that has exhaled air in it?

Materials

Brom-thymol blue
Limewater
Straws
2 test tubes
Test tube rack
Two 2-hole rubber stoppers
Collecting bottles
Glass tubing
Rubber tubing
Glass Y-tube
Matches

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 20

Problem: In what ways does the air we inhale differ from the air we exhale?

Materials

Two 6" test tubes
Limewater
Brom-thymol blue
Straws
Candle
Collecting bottle
Rubber tubing 12"
Glass plate
Rubber stopper for test tube

Procedures

1. Place your straw into one of the test tubes that contains limewater and exhale into it.

   CAUTION: — Do not exhale too vigorously.

2. Explain what the color change shows____________________.

3. Place the rubber stopper in the other test tube and shake for several minutes.

   What do you notice?____________________

   What reason can you suggest for for this?____________________

   Which test tube showed more of a color change?____________________

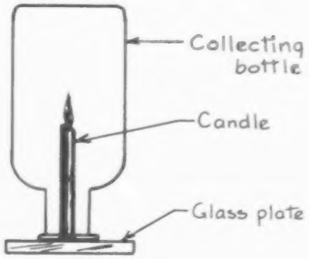
   What does this show?____________________

4. Place the candle in a few drops of melted wax on the glass plate. *Avoid* getting your sleeves, ties, or hair near the candle flame. When your teacher tells you to start, turn the glass bottle upside down over the burning candle as shown. As your teacher starts counting off the seconds, measure the time that the candle burns inside the jar.

   Candle burns____________________seconds.

   Why did the candle stop burning?____________________

   Where did the oxygen come from?____________________



5. Light the candle again.

6. Now take a deep breath and hold it for 10 seconds as your teacher counts.

   NOTE: Do not do this if you have any trouble in breathing.

   Then place a straw in your mouth and blow the air from your lungs into the bottle that is held upside down. Keep the other end of the straw well inside the jar. Set the jar quickly (without turning it over) over the burning candle you used before. As your teacher counts again, measure the time the candle burns.

   Candle burns____________________ seconds.

   Compare this number with the other amount. Was there a difference?
   ____________________ Explain why.____________________

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Summary

1. Why did the candle stop burning inside the jar? ________________
2. Why did the candle burn for less time inside the jar with the exhaled air? ________________
3. What happened to this oxygen? ________________
4. How did the limewater show there was more carbon dioxide in the exhaled air than in the air we breathe in? ________________

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21. WHAT ARE THE MECHANICS OF BREATHING?

LABORATORY LESSON

Outcomes

- Breathing is an automatic process.
- *The concentration of CO_2 in the blood controls the mechanism for breathing.*
- The movements of the diaphragm and the ribs change the size of the chest cavity, thereby changing the pressure inside the cavity.
- *The thoracic cavity is completely closed.*

Motivation

Ask the pupils, "Did you ever try holding your breath under water?" Then follow with, "What happened? How did you feel?"

Development

1. List answers on the chalkboard. Elicit possible reasons for their sensations. Ask, "If a person is unconscious, is he still breathing?"
2. Develop the understanding that breathing is automatic and, once started at birth, continues without any help from us.

2a. Discuss with pupils, how the concentration of CO_2 in the blood influences the mechanical process of breathing.

3. Have pupils breathe in and out deeply, while touching their ribs, and watching their stomachs. Ask, "What did you feel and see?"

4. Lead pupils to the understanding that inhaling and exhaling are brought about by muscular actions affecting the ribs and chest. Demonstrate by means of the Bell jar apparatus.

5. Have pupils recall the structure of the diaphragm, ribs and the rib muscles. Develop that the variation in the size of the chest cavity when inhaling and exhaling is controlled by these muscles contracting and relaxing.

   Have them understand that in inhalation the increase in size of the chest cavity "reduces" pressure inside the cavity and lungs, causing "air to rush into the lungs".

5a. Discuss atmospheric pressure as it relates to breathing. Elicit from pupils the positions and actions of the ribs and diaphragm in inspiration *and* expiration.

   Ask, "What produces intrathoracic pressure?"

6. Ask pupils, "What do inhaling and exhaling accomplish?"

6a. Recall discussion on diffusion. Elicit which gases are being diffused in respiration.

7. Tell pupils that we are going to make a model of the respiratory system.

8. Distribute Worksheets and guide pupils in carrying out the procedures.

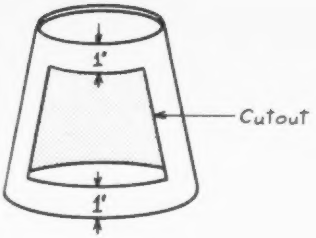
Homework

1. How do pressure changes within the chest cavity cause inhalation, and exhalation?
2. What changes would you expect to occur in your blood, if you were to hold your breath for a long period of time?
3. Explain how the diaphragm, ribs and rib muscles aid in breathing.
4. *Why does the rate of breathing increase rapidly after strenuous exercise?*

Materials

Bell jar
Model of respiratory system

NOTE: Prepare in advance — a paper cup or container with a cutout section covered with plastic wrap.



(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 21

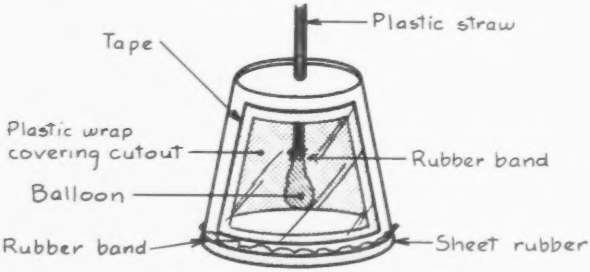
Problem: How can we construct a "Model" respiratory system?

Materials

Large paper cup or quart-size milk container with window cutout	
Plastic wrap	
Balloon	Sheet rubber, 5" square
Plastic drinking straw	2 rubber bands

Procedure

1. Punch a small hole in the bottom of your cup just large enough to permit a straw to fit through.
2. Blow your balloon up partially several times. Let all air out of it. Attach it to the straw with a rubber band.
3. Push the other end of the straw through the round hole in the cup. Pull the straw until balloon is inside the cup.
4. Put the sheet rubber over the top of the cup. Secure by wrapping a rubber band around the cup.


Tape
Plastic straw
Plastic wrap covering cutout
Rubber band
Balloon
Rubber band
Sheet rubber

5. **Hold model in one hand so that you can see the balloon through the plastic wrap.**

6. **Pull down and then push up the rubber sheet. Observe the balloon.**

Summary

1. **What happened when the rubber sheet was pulled down and when it was pushed up? ______________________________**

   ____

2. **Why do you think this happened? ______________________________**

   ____

3. **Compare your model with the respiratory system in man. (Use your diagram from homework in previous lesson.) Which part of the respiratory system does the same job as each part of the model?**

   a. **Open end of drinking straw ______________________________**

   b. **Drinking straw ______________________________**

   c. **Cup ______________________________**

   d. **Balloon ______________________________**

   e. **Rubber sheet ______________________________**

4. **What differences do you see between your model and the diagram?**

5. **What causes us to breathe in (inhale) and to breathe out (exhale)?**

   ____

EXCRETION

Suggested Lessons and Procedures

22. HOW ARE WASTES FORMED?

Outcomes

- The burning of food by our bodies produces heat, energy, and wastes.
- *Urea is a waste product from proteins.*
- The gaseous and liquid wastes are formed by the burning of food by the cells. The solid wastes are the undigested part of the food we eat.

Motivation

What is left after wood or coal is burned in a furnace? What must we do with these?

Development

1. Relate the burning of fuels in a furnace to produce heat to the burning of food in our bodies for energy and heat. Ask, "What is necessary in order for burning to take place?" Recall that oxidation and cell respiration (Grade 7 Biology unit) are the means by which our bodies gain energy to carry on life activities.
2. Demonstrate some by-products of burning by the following:
   a. Light a marshmallow.
   b. Hold it near a polished sheet of aluminum, or an aluminum pot.

c. Have pupils observe the formation of water vapor, heat, and light.

3. Compare with the oxidation in our bodies by exhaling on the chalkboard to show moisture. Have pupils exhale with hands over their mouths to feel warm air.

4. Recall that blowing through a straw into limewater turned the limewater cloudy. Have pupils conclude that another waste product of oxidation is carbon dioxide.

5. Ask what happens to the parts of the food we eat that cannot be digested. Elicit that these parts form the solid waste which passes into the large intestine.

5a. Explain to the pupils that the lining of the large intestine eliminates excess calcium and iron with the feces.

6. Discuss the role of the large intestine. Review the tube-within-a-tube concept of the digestion system. Refer to the chart of the digestive system. Elicit that the waste material which goes into the large intestine may contain much water, but that the relative amount of water which is eliminated is smaller. Ask, "Where do you think it went?" Discuss the function of the large intestine to retain (re-absorb) water in the body. Ask, "What causes constipation?"

6a. Elicit the location of the appendix. Ask, "What is its function in man?" "Why is it called a vestigial structure?" "What causes appendicitis?"

7. Ask, "What are some other solid wastes that the body has to dispose of?" Guide the pupils to the understanding that other wastes are formed and their accumulation would be harmful to the body. Elicit that urea (which is formed from protein and protoplasm) and salt are soluble and go into the blood to be carried away to the organs of excretion.

7a. Discuss the formation of urea.

Summary

1. What do we call the parts of food that the body can't use?
2. What are the by-products from the burning of food by our cells?

3. Name three different wastes that are formed by our bodies and tell how and where each is disposed of.
4. *How is urea formed?*
5. *What is meant by cellular respiration?*

Homework

1. How are body wastes formed by our bodies?
2. What waste is produced from protein foods?
3. Name three parts of the body which help to excrete wastes.
4. How does the large intestine help us to retain water?
5. *If you have a pain in your stomach, why should you not take a laxative?*
6. *Explain the formation of urea from proteins.*

Materials

Marshmallows
Aluminum pot, or sheet
Matches
Tongs or thin stick
Chart of digestive system

23. HOW ARE SOME WASTES REMOVED FROM THE BODY?

Outcomes

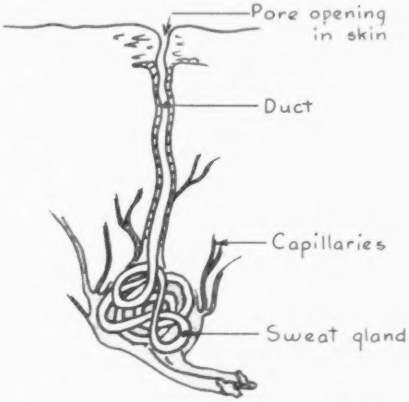
- The skin and the kidneys are the main organs which remove liquid waste materials from our body.
- Both sweat and urine are mostly water, but also contain salts and urea.
- Evaporation of sweat cools off the body.

Motivation

Ask the pupils, "Who will feel cooler after doing the same amount of exercise, a person who sweats (perspires) or a person who does not sweat?" Elicit that perspiration cools our skin and body.

Development

1. Demonstrate the cooling effect by having the pupils hold both index fingers near each other and blow air over them. Ask which finger feels cooler. Allow them to wet the left index finger and then blow air over them again. Ask, "Which finger feels cooler now?"
2. Elicit that the water on the left index finger evaported Lead them to understand that evaporation removes heat. Ask, "Where did the heat needed to evaporate the water come from?" Have them conclude that when heat is removed from our skin, we feel cooler.
3. Relate the wet finger to sweat on our skin. Ask pupils, "Where does the sweat come from?"
4. Display a model or chart of a cross-section of our skin, and have pupils draw the diagram of skin and sweat gland.



5. Compare the villus of the small intestine to the sweat gland that is surrounded by capillaries. Conclude that "materials dissolved in water can pass through a thin membrane." Elicit from previous learnings that the blood contains water, salts, and other wastes, such as urea. Lead the pupils to conclude that these wastes leave the blood by diffusion through the thin membrane in the sweat gland, and come to the surface through the pores.

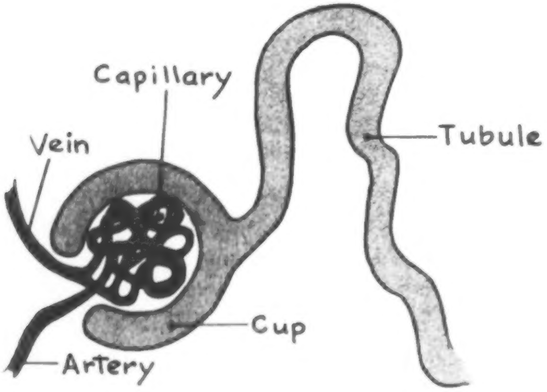
Asking pupils to describe the taste of sweat, confirm that it has a salty taste. Relate this to the need for frequent washing to prevent body odors.

5a. *Discuss the distribution of the pores on various areas of our skin. Compare to other animals such as dogs. Elicit how dogs sweat.*

6. With the help of a model or chart, trace the path of waste products as they: a) diffuse from the blood; b) collect in the kidney; c) flow through the ureters into the urinary bladder and stored there until it can be eliminated through the urethra.

7. Develop the understanding that most of the liquid wastes containing urea (from protein and protoplasm breakdown) are eliminated by means of the kidney as urine.

7a. *Shows a chart or diagram of a kidney tubule and indicate capillary diffusion into the cup-like structure. Develop that the kidney is composed of many such "cups" which receive the urea, water and salts and forms urine.*



Summary

1. Why do we feel cooler when we are wet?

1a. *Why do dogs "pant"?*

2. What is left on the skin after the sweat evaporates?

3. Where does diffusion take place in our body?

4. *In what ways are the sweat glands and the cups in the kidney alike, in function and in structure?*

5. *What does an artificial kidney do?*

Homework

1. In what two ways is perspiring useful?

2. What waste products are removed by the skin and by the kidneys?

2a. What diseases can be diagnosed by a urine analysis?

3. Why is it that diffusion takes place where there are large networks of capillaries?

4. How does heavy eating of proteins affect the urine composition?

Materials

Charts and models of skin, kidney, and excretory system
Beaker of water

24. *WHAT CAN AN ANALYSIS OF URINE TELL US?

LABORATORY LESSON

Outcome

- An indication of the health of the body may be obtained by means of an analysis of urine.

Motivation

"Why does a doctor ask for a sample of your urine when you go for an examination?" Elicit that the doctor (or his laboratory) performs chemical tests to see what is present in the urine.

Development

1. Help pupils recall the formation of waste products by the body and the diffusion of these wastes into the blood.

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* Only for classes programmed for five periods

2. Ask, "What waste materials would you expect to find in the urine?" "How can we test for these materials?"

3. Have the pupils understand that the kidneys help keep the composition of the blood constant, by removing excess substances. If there are any excesses of certain materials (i.e., sugar), this may indicate defective health.

   Ask, "How can this be detected by testing the urine?" Elicit suggestions as to materials that might be present for which tests can be made.

4. Tell pupils that they will try to analyze a sample of *artificial urine*, to see what it contains.

5. Review how we can test for an acid, using litmus paper, and discuss the chemical tests for sugar and salts.

6. Distribute Worksheets and materials, and caution pupils regarding the handling of the alcohol burner. Guide the pupils to follow the specific instructions on the Worksheet.

   NOTE: Artificial urine may be prepared as follows: To 1000 ml of water add 10 grams of glucose or dextrose, 5 grams of sodium chloride, and 10 grams of urea (S-1 List). Tea may be added to impart the desired color. Be sure to check the reaction of the urine with litmus paper. Make certain that the urine is slightly acid. If necessary, add drops of dilute hydrochloric acid. Urease (S-1 10-4248) is also available at drugstores.

Homework

1. What substances are usually found in normal urine?
2. Is urine acid, base, or neutral?
3. Why is a urine analysis helpful and important to a doctor?

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 25

Problem: What can an analysis of the composition of artificial urine tell us?

Materials

Bottle of artificial urine
Red and blue litmus paper
Test tube rack with 3 test tubes
Test tube holder
Alcohol burner
Medicine dropper
Small graduated cylinder
Urease tablets
Dropper bottles of Benedict's solution and silver nitrate
Phenolphthalein

Procedure

1 Using the graduated cylinder, place 5 ml of urine into each of the three test tubes.

2. Place a drop of urine on each piece of litmus paper.
Is there any change in color?________________
The blue litmus paper________________
The red litmus paper________________
This shows that the urine is (acid, base, neutral)________________

3. Using the graduated cylinder, pour 5 ml of Benedict's solution into the first test tube. Heat it gently over the alcohol burner. Be careful to keep hair, sleeves and ties away from the flame.
Is there a color change?________________
Describe it.________________
This indicates that the artificial urine (does, does not) contain________
NOTE: in good health, sugar is not usually present in urine.

4. Add a few drops of silver nitrate to the second test tube of urine.
What did you observe?________________
This shows that the artificial urine (does, does not) contain________________

5. To the third test tube of urine, add one tablet of urease and a few drops of phenolphthalein.
What did you observe?________________
(a change to a red color indicates the presence of urea)
This shows that the urine (did, did not)________________contain urea.

Summary

1. What substances were found to be in the artificial urine you tested?
____

2. How can urine analysis be used to see if the liver and kidneys are working properly?____

BEHAVIOR

Suggested Lessons and Procedures

25. HOW DO OUR SENSES HELP US TO REACT TO OUR SURROUNDINGS?

Outcomes

- The human body is equipped with sensory receptors that aid in determining how we react to our surroundings.
- Reactions to environmental conditions vary with individuals.
- Behavior is the result of reactions of the human body to surrounding conditions.

Motivation

Without warning, strike the side of your desk with a ruler. Ask, "Why did we react the way we did?"

Development

1. Elicit from the pupils what enabled them to hear the sound of the ruler against the desk. Invite pupils who have pets to describe how their pets seem to hear sounds that we do not. Why?
2. Have pupils name the "senses" and list them on the chalkboard together with the organ *(receptor)* with which each is associated.
3. Briefly demonstrate with the aid of the pupils, the different senses and how they help us to react to our surroundings.

3a. Elicit from pupils the types of taste receptors in the tongue and where they are located, i.e., bitter, sour, sweet tastes.

a. Blindfold a pupil and have him stick out his tongue. Squeeze a piece of lemon so that a drop of juice lands on his tongue. Have pupils observe his reaction. Ask, "What sense was he using?" Have him try to locate where he sensed this taste on his tongue (front, back, side, etc.). Compare with his reaction to sweets.

b. Ask the blindfolded pupil to attempt to cross the room. Be careful that he doesn't fall. Have the pupils observe what action he takes in his attempt to cross the room. Ask another blindfolded pupil to describe and identify an object by feeling it.

c. Put a piece of plate glass on the desk top. Scratch the glass with your fingernails to produce a sound. "Why did some pupils scream?" "Why did some people react differently?"

d. Using coded bottles of very dilute ammonia, and dilute solution of perfume, ask two pupils to smell them. Remind the pupils of the proper method for smelling chemicals. Observe the two pupils' reactions as they smelled the two bottles. Ask, "What were the reactions to the different smells? Why do we react the way we do to different odors?"

e. Have one pupil close his eyes for one minute and face the window. Have another pupil observe the first pupil's eye after he opens it. Ask, "What was the size of the opening at first? How did it change? Why do you think it changed?" Ask about situations that will cause this kind of reaction in the eyes.

3e. What "sense" does man rely upon most?
Ask, "How do we see with our eyes?"

4. Develop the understanding that we have more senses than the localized four that were just studied.

4a. Discuss varieties of sensations — pain, heat, cold, pressure, etc.

5. Refer to the motivation. Discuss how pupils responded differently to the sound of the ruler, also to the sound of the scratched glass.

5a. Elicit reactions to these stimuli. Do we all react the same way to these stimuli?

Elicit from the pupils that sensations from our surroundings affect (stimulate) our sense receptors causing action (response). *Behavior* consists of *responses* to *stimuli.*

Suggest the classic example of "the finger to the hot stove". What is the reaction of a small child?

6. Discuss the fact that the sense reception of all individuals is not the same, therefore the reactions to stimuli vary. Ask, "What difference have you noticed in animals' reactions to smell and sounds, and in yours?" Refer to the reaction of animals to sounds in the 'jungle' movies pupils have seen, e.g., gazelles, giraffes, and birds.

6a. *Discuss compensation for defects in senses, i.e., blind man depends upon acute hearing and touch. "How can sense reception be developed more effectively?"*

Encourage the pupils to understand that the sense organs vary in structure from simple nerve endings to rather complex organs like the eye and the ear.

7. Lead the pupils to see that the stimuli from our surroundings determine our behavior.

Summary

1. What do stimuli from our surroundings cause?
2. What is the nature of most of our reactions to stimuli?
3. What are the four localized sense organs?
4. Where do the sensations we receive come from?
5. Why are some people's and animals' senses more acute than others?
6. How do we define behavior?

Homework

1. Why did some pupils scream when the glass was scratched?
2. What were the reactions to the chemicals in the two bottles? Why?
3. Why did the opening in the eye change in size?
4. In the table, indicate how your family members react to:
   a. Loud sounds (radio or TV)
   b. Different foods (lemon, onion, garlic, sweets)
   c. Amount of light
   d. Different odors

REACTION TO:	MOTHER	FATHER	BROTHER	SISTER	YOURSELF

Materials

Lemon wedge, or juice	Glass plate
Dilute solution of ammonia	Blindfold
Dilute solution of perfumed liquid	Ruler

26. HOW CAN OUR SENSES FOOL US?

LABORATORY LESSON

Outcome

- Our responses depend upon the stimuli or signals received by our senses.

Motivation

Place 3 battery jars on the lab table. Place some ice water into the first, water at room temperature into the next, and very warm water into the third.

CAUTION: Do not use very hot water.

Ask pupils if they think they can judge the temperature of the water in the middle jar by feeling it with their hands.

Development

1. Have 2 pupils come up. Ask one to place his left hand into the first jar. Ask the other pupil to place his left hand into the third jar. After about 30 seconds, ask each one, in turn, to place his left hand in the middle jar.

   Ask each pupil to write on the chalkboard his reaction to the temperature of the middle jar. "Was it cold?" Was it warm?"

2. Ask the 2 pupils to explain why they think they gave different estimates about the water temperature in the middle jar.

3. Have them conclude that they each have received the same stimulus but their sense of touch was fooled because each had received different stimuli just before.

   Have them understand that this is an example of an *illusion.*

   a. Place a heavy weight (lead sinker) inside a paper bag and tie the bag so that the pupils do not know what is inside.

   b. Take another object of the same size and shape (light weight) and wrap it in another bag in the same way. Place both of these bags on the edge of the table.

   c. Have a pupil who does not know what is inside the bags come up. Tell him that he is to try to lift both bags, one in each hand, evenly and at the same time.

   d. Ask pupils to watch both hands. Ask, "What did you observe?". "What explanation can you give for this?"

   e. Take the weights out of the bag. Ask the same pupil to try it again. Ask, "Was there any difference in the way he acted the second time? Explain why you think this happened."

   f. Lead the pupils to conclude that our eyes received what appeared to be the same stimulus, and our muscles anticipated the same effort would be needed to lift each bag. But the second time our muscles were ready for the extra effort required to lift the heavy weight.

5. Tell the pupils they will now perform several activities to show other examples of illusions. Distribute the worksheets and materials and have the pupils follow the written directions.

Materials

3 battery jars
Ice
Bunsen burner
2 paper bags
2 bottles

Enrichment Activities

Discuss the following:

1. *The formation of mirages in the desert.*

2. *The appearance of wet areas on the highway on a sunny day.*

3. *The distortion of objects when seen through certain lenses or under water.*
4. *The formation of an image in the brain from light stimuli.*
5. *The manner in which our brain inverts the image that it actually receives.*
6. *The distortions and changing images we perceive in op art.*
7. *The substitution of colors due to retina "fatigue".*

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 26

Problem: How may our senses fool us?

Materials

Ruler
Index card
Pin
Pencil
Sheet of paper
Hairpin

Procedure

1. Place the tips of your index fingers together, holding them about 3 inches directly in front of and level with your eyes. Look *past* the fingers, focusing your eyes on the chalkboard. Now separate the tips of your fingers about half an inch.

   Describe what you see____________________________________

   Is it really so?____________________

   Lead pupils to understand that this is an example of an illusion — involving sight, an optical illusion.

2. Draw four heavy lines on the index card as shown. Push the pin through the center and, holding the pin, spin the card.

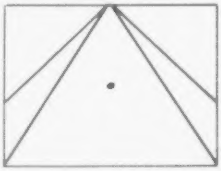
   What do your eyes "see?"________

   ____

   Is it really there?_______________

   What is this called?

   ____



3. Roll a sheet of paper into a tube. Put one end of the paper tube to your right eye, like a telescope, and hold your left hand, fingers extended, palm toward you, against the tube. Both eyes must be kept open. Focus your vision on the chalkboard.

What do you "see"?____

Are you really looking "through" your hand?____________________

4. Bend a hairpin until its points are about one inch apart. Place these points evenly on your arm above your elbow. Close your eyes.

   How many points do you feel?____________________

   Open your eyes and look. What do you see?____________________

   Have pupils conclude that this, too, is an illusion — where our sense of touch fools us.

   Place the hairpin points on your fingertips. What do you feel now? ____________________What can you conclude about the locations of the receptors from this experiment?____________________

Summary

1. Can we always be sure of what we see or feel?
   Explain.____
2. Explain why using more than one of our senses gives us more accurate information.____

Homework

1. What part of our hand is most sensitive to touch? How did you determine this?
2. In what ways can illusions be harmful?
3. Take a large pot, and pour what you think is a cupful of water into it. Now pour this into a cup. How good was your judgment?
4. Cut what you think is 2 feet of string. Measure what you have cut with a ruler. How well did you estimate the two feet?

27. HOW DOES THE BODY REACT AUTOMATICALLY TO SOME STIMULI?

Outcomes

- Reflex actions are simple responses to stimuli from within and without the body.
- Reflex actions are frequently protective.

- **Many reflex actions are automatic, and cannot be controlled.**
- ***The reflex arc makes reflexes possible.***

Motivation

Ask pupils, "What would your reaction be, should someone unexpectedly walk up behind you in the dark and shout?"

Development

1. Elicit that the action (jumping, drawing away, screaming) is automatic and helps to protect us. This is called a reflex. Identify the stimulus (sound) and the response *(reflex action)* in behavior.
2. Exhibit pictures of some favorite foods such as ice cream and cake. Ask the pupils to describe what happened in their mouths. Elicit reasons for salivating. Again, identify the stimulus (food) and the response (salivating.)
3. Ask pupils to describe the simple kneejerk action experienced in the doctor's office. Ask, "Why does the leg jerk upward? Did you have to think about it?"

   NOTE: The teacher may demonstrate this reflex action on himself if he desires.

4. Demonstrate other reflex actions by the following:
   a. Have a pupil hold a piece of screen wire against his face. Another pupil will throw a loosely wadded ball of paper (prepared by the teacher) at him, aiming at his face. Have the pupils observe the closing of the eyes. Ask, "Why did he blink?"

4a. Using appropriate charts and diagrams, draw and identify a reflex arc. Elicit that in the case of a reflex action, the thinking part of the brain may be by-passed so that the response is quicker. Cite such examples as touching a hot object.

   b. Ask one pupil to face the window, keeping his eyes closed for approximately one minute. When he opens his eyes, a second pupil will observe the contracting of the openings in the eyes (pupils).

   NOTE: A flashlight beam directed into the eyes will also work effectively.

c. Discuss sneezing as a reflex. Have a pupil tickle the inside of his nostril with a hair or piece of thread. Ask, "How does a sneeze help you?"

5. Guide the pupils to understand that reflex actions are controlled by the spinal cord and the brain. Refer to the chart of the nervous system. Elicit from pupils the path of a spinal reflex in simple terms, i.e., sense organ to spinal cord and, usually, to brain and then to muscle. Trace this with one of the reflexes discussed previously.

6. Develop the understanding that many reflexes protect the organism. Ask, "What would happen if you did not close your eyes on exposure to bright light?" Develop the fact that the response which is automatic is also immediate. This is necessary for protection.

6a. Discuss instincts as they relate to self-preservation. Ask, "What will all animals do in time of danger?"

7. Tell the pupils that not all reflexes are as simple as the knee jerk. Ask pupils what their reactions would be if they stepped out of bed, expecting to step into their slippers, but stepped on a sharp object with one foot. Have them understand that many actions will follow, e.g., both legs, heart, hands, and even the brain.

8. Develop the understanding that spinal reflexes may be brought about as a result of stimuli inside the body as well as outside the body. Ask, "What happens to the skin when it becomes chilled?" "How do we know when we are hungry?" These actions are also protective.

8a. Discuss with pupils the parts of the body that may be involved in spinal reflexes.

Why can a person do things in time of danger or emergency he could not ordinarily do? Point out that the danger stimuli causes the heart to beat faster and oxidation of sugars for more energy.

Summary

1. What happened to your salivary glands when the picture of food was shown. Why?

1a. What makes reflexes possible?

2. Why are we unable to control the blinking of our eyes when an object comes toward them?

2a. Why is the spinal cord alone unable to react to a stimulus?

3. What causes reflex actions?

4. Of what use are some reflex actions to us?

5. What parts of the body are affected by simple reflex actions?

Homework

1. What is a stimulus and a response? Give examples of each.
2. Explain how reflexes protect us.
3. *Draw a labelled diagram of a simple reflex action (knee jerk).*
4. *What are instincts?*

Materials

Chart of nervous system
Screen wire
Flashlight
Paper wad

28. HOW CAN OUR RESPONSES BE CONDITIONED?

Outcomes

- Behavior may be in the form of *conditioned responses,* a type of learned behavior.
- *Acquired reflexes are ones we learn by repetition of performance.*
- Conditioned responses, reactions to substitute stimuli, are usually helpful. However, they may sometimes be harmful.

Motivation

Tell the story of the scientist Pavlov and his experiment with a dog. A dog normally salivates when he gets food. At first Pavlov fed his dog at a regular time and rang a bell just before feeding time. The dog associated the bell sound with food, and after a while, started salivating whenever he heard the bell, even when not fed.

Development

1. Ask, "What was the original, natural stimulus in this case? What was the response?" Develop that a different stimulus was substituted (bell), but the same response (salivation) was evoked. Tell the pupils this is called a *conditioned response* or reflex.

2. Discuss "learned behavior" as conditioned response, both in animals and in humans. Have pupils cite examples of how they train their pets, developing conditioned reactions so that the animals obey at a command or given signal. Ask, "How is our learning at school a form of conditioning?"

2a. Develop that acquired or learned reflexes are dependent upon the highest levels of thinking. Ask, "Why doesn't a professional typist, or piano player, have to look at the keys?"

3. Have the pupils watch you slice a lemon. Ask, "What happens to your salivary glands? What is the stimulus now? What was the original stimulus? How did your reflex become conditioned?"

4. Suggest to the pupils some of our other reflexes that have become conditioned, e.g., our reactions when we hear a carhorn blow behind us, our response to the end-of-class bell before lunch period.

5. Elicit from the pupils how reward and punishment can condition our behavior. Refer to training of animals. Ask the pupils what kinds of rewards and punishments have been used to condition their own learning and their behavior.

6. Discuss the role of conditioning in developing attitudes. Ask, "How would you feel about the Martians if you were told constantly that they were bad, that they had a purple color and had different customs and beliefs? Would you be prejudiced against them?" "How have some of us become prejudiced against certain foods, against certain beliefs, against certain people?" "Do you know of any countries where such prejudices have been taught?" Discuss further how some people are "more conditioned" than others, and how such conditioning may be overcome. Ask, "Is conditioning always helpful?"

6a. Discuss learning as conditioned behavior. "What does brainwash-

ing mean?" Discuss teaching and learning in democratic and totalitarian societies.

7. To illustrate conditioning, ask the pupils to follow your instructions:
   a. Walk to the rear of the room, where they cannot see you.
   b. Tell them to draw a small circle on a sheet of paper each time you say, "Write".
   c. Use a ruler to tap on the desk each time you say, "Write". (Count the number of times you say this.)
   d. After about 15-20 times, stop saying "Write" and continue to tap on the desk with the ruler for about the same number of times.

   Ask the pupils to count the number of circles on their paper. Make a record of these on the chalkboard. Ask, "Why doesn't each person have the same number of circles? Why did some pupils continue to draw circles when I didn't say *write*? What has happened to these pupils?"

8. Elicit from the pupils how conditioned behavior may be time-saving, helpful, or convenient. "What do we do when we observe a red signal light?"

Summary

1. What did the story about Pavlov's dog show?
2. Are conditioned responses always good? Explain.
3. How do rewards help you to learn better?
4. *How can conditioned responses be changed, or unlearned?*

Homework

1. Explain the steps you would take to train your dog, or other pet, to obey your commands.
2. What is a conditioned response?
3. Play the game "Simon Says" with your family. Why do we make mistakes playing this game?

4. List some advantages of conditioned responses.
5. *Why is typing considered a conditioned reflex?*

Materials

Paper	Knife
Pencils	Ruler
Lemon	

29. WHAT PARTS OF YOUR BODY CONTROL BEHAVIOR?

Outcomes

- The nervous system is composed of the brain, spinal cord, and nerves.
- Different parts of the brain control different functions. The spinal cord controls certain reflex actions. The nerves carry messages to and from the brain and spinal cord.
- The skull, spinal column, fluid and skin protect the nervous system.
- *The autonomic nervous system performs an important function.*

Motivation

Ask the question, "Is it true that we see, hear, and walk with our brains?" "Explain." Elicit that the brain is involved in nearly all of our actions.

Development

1. Ask the pupils, "What are the main parts of the nervous system?" With the aid of a model and charts of the nervous system, trace the spinal cord as it connects to the brain. Identify this as the central nervous system.
2. Demonstrate a fresh calf brain (if available), or model. Show that there are 3 main parts; the cerebrum (forebrain) which controls such things as thought, senses, memory, and emotions; the cerebellum (midbrain) which controls balance and motion; and the medulla (hindbrain) which controls the activity of the internal

organs, such as heartbeat and respiration. Guide the pupils in making a labelled drawing of the brain.

2a. *Discuss briefly the evolution of the brain from lower forms of animals. Where possible, use charts or models to compare structures.*

3. Ask, "Which part should be more highly developed in man than in lower animals?" Lead pupils to understand that the cerebrum, which controls thought and learning, is the largest part of the human brain. Ask, "Why will a cat almost always land on its feet when thrown into the air or when jumping. What part of the brain has been responsible?" "Why is a rabbit punch so dangerous?"

3a. *Discuss the structure of the cerebrum, where certain capacities are controlled by specific areas, i.e., speech, as shown by brain damage as in a stroke.*

4. Have pupils recall how the spinal cord controls simple reflex actions of the body, and how the brain is responsible for many actions. Ask, "How does the central nervous system communicate and work with the rest of the body?" By means of a chart or model, point out the nerves branching from the spinal cord to the organs and other parts of the body.

4a. *Compare the nervous system with a telephone network.*

5. Elicit the function of nerves. Tell pupils that nerves vary in size and length (from very long fibers to a single nerve cell), and perform 3 main duties; a) carry messages to the central nervous system; b) carry messages from the central nervous system; and c) connect these. Elicit that action of muscles, which have received messages by means of nerves, leads to physical movement. Show the pupils a picture or chart of a single nerve cell (neuron) and point out the main parts.

5a. *Discuss the pathway of the impulse through the nerve cell. "What is a synapse?"*

b. *Differentiate between the central nervous system and the autonomic nervous system (31 pairs spinal nerves).*

c. *Discuss the inability of nerve cells to reproduce.*

6. Display a human skull and vertebrae (or have the pupils recall the skull and backbone as seen in pictures). Elicit the function of the

skull and spinal column. Ask, "Why do nerve cells need to be protected?" "What protects the nerves in our hands, arms, and legs?"

6a. Discuss some of the following: regions of the spinal column and location of specific vertebrae; "slipped disc" and other difficulties; concussion of the brain; spinal meningitis.

Summary

1. Name the parts of the brain and give one main function for each part.
2. Suppose you are riding a bicycle and suddenly a car comes at you from a side street. Describe the steps involved which affect your immediate behavior.
3. How is the central nervous system protected?
4. *What is the difference between the central and autonomic nervous system?*
5. *Why is damage to the brain so serious?*

Homework

1. Why do some prizefighters become "punch-drunk"?
2. Why is man considered the highest form of animal?
3. What are the 3 main jobs of nerves?
4. *How have we been able to "map out" the various parts of the brain and their functions?*
5. *What are several ways in which the brain might be damaged?*
6. *Draw a labelled diagram of a neuron.*

Materials

Charts of the nervous system
Human skull (if available)
Vertebrae (spinal sections)
Model of human brain
Model of human spinal cord
Fresh brain specimen (calf)

30. *WHAT ARE SOME METHODS WE USE IN LEARNING?

LABORATORY LESSON

Outcomes

- In the trial-and-error method of learning, we can learn from our mistakes.
- We can learn by rote memorization.
- We learn things by reasoning.
- We learn best when we are not distracted.

Motivation

Hold up your set of school keys on the ring and ask a pupil to come up. Ask him to try to unlock your closet door. Ask the rest of the class to observe how the pupil goes about finding the correct key.

NOTE: Select a pupil who has *not* handled your set of keys before.

Development

1. Elicit from the class that the pupil does not know which key to use. Ask, "How is he finding the proper key?" Ask if this is an efficient method of finding out. "Could he have used any other methods? Explain." Have the pupils understand that their classmate tried one key, failed, tried another, failed, and so on, until he was successful. Lead them to understand that this is what is known as the trial-and-error method of learning.
2. Write on the board, the first and last letters of the word *learning* using a dash in place of the missing letters. Call upon several pupils to supply the missing letters, to learn what the word is. Ask them what method they are using.

   As several letters are used, and some blanks filled in, ask pupils if their task is now easier than at the start. Elicit that as the letters are filled in, more is known about the word. They also have fewer choices (trials) to make.

   Ask them if they can see any reason for starting their choices with the vowel letters. Have them understand that they have increased their chances by using *reason* — another method of learning. Ask, "Did you learn anything from their mistakes?"

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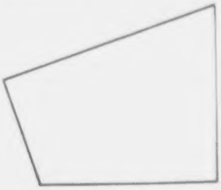
* Only for classes programmed for 5 periods

3. Tell them they are going to see other factors involved in learning. Distribute Worksheet and materials. Guide the pupils so that they understand the written directions.
   a. With the help of some pupils, cut 4 pieces of cardboard identical to the shape in the diagram, and place in an envelope, one set for each team of pupils.



   b. Rexograph 2 stanzas of a simple poem. Cut to separate the stanzas of the poem. A suggestion follows:

There was a young lady, named Bright
Who travelled much faster than light.
I. She started one day
In a relative way
And returned on the previous night.

There was a young lady of Niger
Who smiled as she rode on a tiger.
II. They returned from the ride
with the lady inside,
And a smile on the face of the tiger.

   c. As the pupils start to memorize the first stanza, maintain silence in the room. As they start on the second stanza provide as many noisy distractions as possible, talking, walking, humming, tapping, etc.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 30

Problem: What are some methods we use to learn things?

Materials

2 poems (separate sheets)	4 oaktag shapes	Pencil and paper

Procedure

1. The teacher will give you a paper with a poem on it. When the teacher says start, memorize it. Raise your hand when you have memorized it. The teacher will record how many can memorize it in a certain time.
2. The teacher will give you another paper with another poem on it. Raise your hand when you have memorized it. What was the teacher doing the second time?____________________

   Was it more difficult the second time?____________________

   What do you think the reason is?____________________

   What method of learning did you use?____________________
3. Remove the pieces of cardboard from the envelope. When the teacher says start, put the four pieces of cardboard together so that they form a perfect square.

   Did you know how to do it right away?____________________

   Did you try many different ways?____________________

   Did you make any mistakes?____________________

   What method of learning did you use?____________________

Summary

1. Describe the trial-and-error method of learning.____________________
2. What type of place would be best for studying or doing homework? ____________________
3. How can reasoning or *thinking through* save time in solving a problem? ____________________

Homework

1. You have ten chemicals. A combination of a certain 3 chemicals will give you a perfume. Describe the method you would use.
2. Describe the method you use to learn the national anthem, or school song.
3. How is this method different from learning the answer to an arithmetic problem?
4. Describe what a good place to study would be like.

Appendix

SUGGESTED REFERENCES

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ENRICHMENT ACTIVITIES

Subject Matter

1. What are the limits of our senses? (What is the faintest sound we can hear? How much light do we need for seeing?)
2. Explain the fact that the eye really receives images upside-down, while the brain interprets it oppositely.
3. Make a report of the RH and other factors found in blood, and how they affect blood transfusions.
4. Use a table of food values to determine the foods which are richest in each of the nutrients.
5. Make a study of air pollution and its effect on the body.
6. How does food digestion in a one-celled paramecium differ from food digestion in man?
7. Ask a first-aid specialist to demonstrate the different methods of artificial respiration and explain the advantages of each.
8. How are radioactive elements used in studies of metabolism and digestion?
9. Investigate the causes and treatment of such diseases as: hepatitis, diabetes, and hypertension.
10. Compare the structure and function of the gills of fish with the lungs of man. Investigate the development of lungs in land animals.

Pupil Projects

1. Make an exhibit or chart, showing how animals are adapted for food getting; i.e., beaks or claws of birds, teeth of animals, mouth parts of insects.
2. Make a collection of animal hearts preserved in alcohol. These can be obtained from fish, chicken, cows, sheep and others, at the butcher store. Note their differences and similarities.
3. Visit a hospital or blood bank and report how blood is typed.
4. Devise and carry out experiments to show the responses of growing plants to light, gravity, and water.

5. Try repeating Pavlov's experiment, using white mice or hamsters as experimental animals.
6. Build a maze or puzzle box to observe trial and error behavior in your pets.
7. Make a model iron lung and demonstrate its operation, explaining how and why it is used.
8. Dissect an animal such as a fish or a frog, and compare the animal's digestive system with the human digestive system.
9. Prepare a large chart of the digestive system, indicate the pH in the organs, and label the regions where different enzymes are produced.
10. Using insects in bottles, study and report on the effect of temperature, and carbon dioxide on them, and measure the rate at which an insect uses up oxygen.

Trips

1. Botanical Garden, Bronx
2. Museum of Natural History, Manhattan
3. Hall of Science, Queens
4. Bronx Zoological Park, Bronx
5. New York Aquarium, Brooklyn
6. New York City Department of Health

Research

1. Investigate and report on the work of William Harvey and Malpighi concerning the circulatory system.
2. Analyze the diet of household pet (dog, cat, parakeet, etc.) and compare it with that of a human.
3. Investigate and report how the lie detector makes use of heart rate, pulse rate, and other body functions.
4. What tests are used by doctors to make diagnoses from blood, urine, and metabolism? Illustrate with diagrams and charts.

5. Report concerning the latest findings on the effects of smoking on the lungs and circulatory system.

6. Report the effects of narcotics, depressants, and stimulants on our nervous system.

7. Investigate and report on the structure of proteins, and the body's need for specific amino acids.

8. How do ADP and ATP enter into energy transfer within cells?

9. Investigate and report on the ways in which foods are fortified with vitamins and minerals.

10. Investigate the manufacture and use of artificial body parts.

TEST QUESTIONS

Multiple Choice

Write in the space at the left the letter preceding the correct answer.

________ 1. The gas that causes limewater to turn milky is

a) carbon dioxide　c) water vapor
b) oxygen　d) nitrogen

________ 2. Gastric juice digests

a) starch　c) fats
b) sugar　d) proteins

________ 3. In the stomach pepsin will digest proteins only in the presence of

a) hydrochloric acid　c) uric acid
b) nitric acid　d) citric acid

________ 4. Nutrients that require little or no digestion are vitamins and

a) fats　c) complex sugars
b) proteins　d) minerals

________ 5. The small finger-like projections lining the small intestine are

a) capillaries　c) lacteals
b) villi　d) glands

__________ 6. Air enters the respiratory system because

a) of a change in pressure exerted by the atmosphere
b) the atmosphere always exerts the same pressure
c) an expanding chest cavity is accompanied by a drop in internal pressure
d) all cells need a steady supply of oxygen

__________ 7. The main function of the circulatory system is

a) to help breathe properly
b) to carry material to and from different parts of the body
c) to support the bones
d) to keep blood inside the body

__________ 8. The best place to observe circulation is

a) in the capillaries
b) in the veins
c) in the arteries
d) at the heart

__________ 9. Each cell in the body

a) provides its own food
b) produces its own oxygen
c) must get a regular supply of food and oxygen
d) does not produce waste

__________10. The job of fighting infection is done by

a) the red blood corpuscles
b) the white blood corpuscles
c) the platelets
d) the hemoglobin

__________11. Plasma carries

a) only red and white cells
b) only oxygen and carbon dioxide
c) only water and gases
d) digested foods, blood cells, water and wastes

__________12. The pulse rate and the heartbeat

a) differ from each other when we sleep
b) are always the same
c) differ from each other in children
d) differ from each other when we exercise

__________13. A waste product which is *not* excreted by the skin is

a) urea
b) carbon dioxide
c) water
d) salt

________ 14. A sense organ which can receive stimuli of more than one basic kind is the

a) tongue	c) ear
b) nose	d) skin

________ 15. A scientist who did experiments on conditional reflexes with dogs was

a) Metchnikoff	c) Freud
b) Pavlov	d) Jung

________ 16. A characteristic which is *not* typical of reflexes is that they are

a) fast	c) predictable
b) protective	d) learned

Completion

Write the word or expression that best completes the statement.

1. Salivary glands are found in__________.
2. The muscular movements that push foods into our stomach is called__________.
3. Bile is produced in the__________.
4. The blood obtains oxygen in the lungs and gives up the gas __________.
5. The process by which the body cells release energy from food is called__________.
6. The substance that gives blood its red color is called__________.
7. Foods are used in the body mostly for growth and__________.
8. The prime purpose of digestion is to make the foods we eat __________.
9. An act that is repeated with great frequency will soon develop into a__________.
10. The most highly complex of all of man's organs is the__________.
11. The action of winking the eye involuntarily is called a__________.

12. The enzyme present in saliva is__________.

13. The emulsification of fats in our body is aided by__________.

14. Digested foods pass from the small intestine into the blood by the process of__________.

15. The process by which blood hardens when exposed to air is called __________.

16. The nutrient that starts being digested in the mouth is__________.

17. The physical digestion of our foods begins in the__________.

18. The gas produced when the cell oxidizes its foods is called __________.

19. The substance in gastric juice that causes milk to curdle is __________.

20. The group of chemicals that help in the digestion of foods is called__________.

21. Most of the digestion of food takes place in the__________.

22. The waste product urea is produced by the breaking down of __________.

23. The organ that helps keep the temperature of our body constant is the__________.

24. The blood vessels that carry blood away from the heart are called __________.

25. The blood cells that have to do with the carrying of oxygen are the__________.

26. The solid part of the blood that aids in blood clotting is the __________.

27. The part of the brain that is involved with the control of thinking is the__________.

28. The reason that blood in the arteries appears brighter red than blood in the veins, is that arterial blood contains more__________.

29. The tiny blood vessels which connect arteries and veins are called __________.

30. The section of the brain that coordinates muscular activity is __________.

Modified True-False

Identify as TRUE if the statement is correct; if the statement is not correct change the underlined word to make the statement true.

__________ 1. One of the purposes of digestion is to make the food molecules larger.

__________ 2. In order to test for the presence of starch, we use Benedicts' solution.

__________ 3. Absorption of most food nutrients occurs in the stomach.

__________ 4. The esophagus connects the mouth with the stomach.

__________ 5. The part of the heart that pumps blood to the lungs is the left ventricle.

__________ 6. Diffusion is the breaking of large particles of fat into smaller ones.

__________ 7. The largest organ in our body is the lung.

__________ 8. Water is one of the wastes products removed by the lungs.

__________ 9. The epiglottis is found in the large intestine.

__________ 10. The blood is composed of 75% solid materials.

__________ 11. Carbon dioxide and oxygen are exchanged in the bronchial tubes of the lungs.

__________ 12. There is a protein in blood plasma called fibrinogen that can change to threads of fibrin.

__________ 13. When we perspire, and our sweat evaporates, our body gains heat.

__________ 14. A response is what the organism does when it reacts to a stimulus.

__________ 15. When we use the trial and error method of learning, we learn from our mistakes.

Matching

Fill in the letter of the word or words in Column II which best matches the statement in Column I.

Column I	Column II
_____ 1. air passages to lungs	A. spinal cord
_____ 2. ash	B. bronchi
_____ 3. air sacs	C. diaphragm
_____ 4. controls reflex action	D. minerals
_____ 5. blood not clotting	E. diffusion
_____ 6. large breathing muscle	F. illusion
_____ 7. digestive tract	G. hemophilia
_____ 8. iron containing compound	H. excretion
_____ 9. kidneys	I. tube within a tube
_____10. mirage	J. hemoglobin

Reasoning Statements

Give a reason for each of the following:

1. Food needs to be chewed thoroughly before swallowing.
2. A room crowded with people should be well ventilated.
3. Blood must travel through a system of vessels before re-entering the same chamber of the heart.
4. Undigested food *is not* absorbed into the bloodstream.
5. The ability of blood to clot is a safety device in external bleeding.
6. The *waste* urea must be removed from the cells of the body.
7. The mucus membrane lining, the digestive and upper respiratory tracts serve as a protector of the tissues of the lungs.
8. It is possible to breathe through the mouth, however it is better to breathe through the nose.
9. After dusting and cleaning in the house, we should clean our noses and throats thoroughly.

10. During hot summer months it is advisable to take more salt into our body.

11. Care should be taken to keep our bodies clean.

12. Urine is often analyzed chemically to give clues to a person's health.

13. The eyes should be protected from damage at all times.

14. The developing of habits should be done with much care.

15. The development of man's brain has enabled him to reach the top of the animal kingdom.

Using Science Words

Complete the statements below using the words from the following list:

esophagus
conditioned reflex
semi-permeable membrane
hydrochloric acid
internal respiration
pupils
urea
pancreas
plasma
diaphragm

1. The __________ are opened more when there is little light.

2. A wave-like movement pushes the food along the __________ of the digestive tract.

3. The substance that causes the stomach to be acidic in nature is __________.

4. The __________ secretes the strongest of the digestive juices into the small intestine.

5. The __________ part of blood is used frequently in combat areas.

6. The release of energy from the food we eat by the cells of the body is known as __________.

7. The __________ is the part of body that separates the chest cavity from the abdominal cavity and aids in our breathing process.

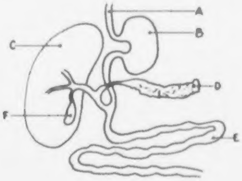
8. The kidneys remove __________ from the blood and get rid of it in the form of urine.

9. The substitution of one stimulus for another to produce the same reaction is known as__________.

10. The digested food that our bodies need for the maintenance of life must pass through a__________to get into the bloodstream.

DIAGRAMS

Questions 1-6 refer to the diagram. Write the letters which best indicate the answers to each of the following statements:



1. Where is bile produced? __________
2. Where are villi found? __________
3. Where are the gastric juices produced? __________
4. Which gland helps keep the sugar content of the blood constant? __________
5. The pancreas is located by which letter? __________
6. The place where bile is stored is __________
7. Peristaltic waves may be observed at __________
8. The digestive tract includes the parts labelled __________ __________ and __________
9. The parts labelled __________ __________ and __________ are included when we refer to the digestive system.
10. At the end of which part is the appendix located? __________

Unit IV

EARTH SCIENCE

The Atmosphere
The Weather

THE ATMOSPHERE

Suggested Lessons and Procedures

1. WHAT IS THE AIR AROUND US MADE OF?

Outcomes

- Air is a mixture of gases.
- The gases in the air are: oxygen (about 20%), nitrogen (about 78%), carbon dioxide (about .04%), and 1-2% of other gases.
- Air also contains pollutants such as dust and gases from factory wastes.
- Air pollution is very serious in large cities such as New York.

Motivation

Wrap a small wad of steel wool around the end of an 8″ length of wire. Ignite the steel wool and place it, while still glowing, into a bottle of air. Place another wad of glowing steel wool into a bottle of oxygen prepared beforehand. (Oxygen may be prepared by placing a pinch of manganese dioxide in a bottle and adding hydrogen peroxide — about 3% solution — to a depth of about ¼″.)

Development

1. Discuss the burning of the steel wool in each jar. Elicit that one of the jars contains "pure" oxygen.
2. Relate the process of burning to the gases in the air. Pose a question such as "Why doesn't everything on the earth go up in flames when we make fires?" Lead the pupils to point out that the air around us is not made of pure oxygen. Review learnings concerned

with mixtures (from the 7th grade). Point out that the gases in the air are mixed together and not combined.

3. **Elicit that the gases in the air do not burn. Encourage pupils to suggest the names of some of these gases. List the names and amounts of each of the following gases on the chalkboard: oxygen 20%; nitrogen 78%; carbon dioxide .04%; other gases about 1-2% (including water vapor).**

3a. ***Demonstrate CO_2 as a gas that does not support combustion. Place a burning splint into a prepared bottle of CO_2 and note the effect.***

b. ***Demonstrate the Geissler tubes to show the rare gases, neon, argon, etc. Have pupils identify the various colors that the gases produce when electrified with an induction coil.***

c. ***Relate the glow to the aurora that occur in the upper atmosphere due to the collision of high energy particles with air molecules.***

4. **Moisten a small section of the chalkboard with a damp sponge. Breathe on a dry part of the board. As the water disappears, ask the pupils, "What happened to the water?" Elicit that it enters the air. Point out that there is always water vapor in the air and that the amount is not always the same.**

5. **Point out the presence of other things in the air. Examples of these are smoke particles, dust, and pollen. Have the pupils recall how they have seen dust floating around in a bright beam of sunlight or artificial light. This may be demonstrated by projecting a beam of light through a cloud of chalk dust.**

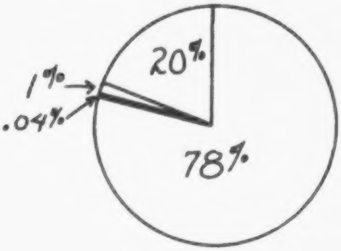
6. **Discuss briefly the problem of *air pollution*. Point out that the pollutants largely come from automobile exhausts and factory chimneys. Large cities, such as New York, have serious air pollution problems.**

Summary

1. **Ask the pupils to name the gases found in the air.**
2. **Have the pupils recall which two gases make up about 98% of the air.**
3. **Question the pupils about the importance of these gases.**
4. **Have the pupils recall that air is a mixture of gases.**

5. Ask the pupils what we find in the air besides gases. Have the pupils point out that large amounts of pollutants are also found in the air.

6. Have the pupils name the gases that belong in each segment of the circle graph. (This may be completed for homework.)



Homework

1. Look around your neighborhood. List at least three things that add dirt to the air.

2. Why is the air in and around cities dirtier than the air in the country?

3. Why do we call air a mixture of gases?

Materials

8″ length of wire
Bottle (containing air)
Bottle of oxygen (use oxygen cylinder or prepare by using $MnO_2 + H_2O_2$)
Sponge

Flashlight or projector
Carbon dioxide gas (marble chips + HCl)
Splints
Geissler tubes
Induction coil

2. WHAT IS THE ATMOSPHERE?

Outcomes

- There are several sections in the atmosphere: troposphere, stratosphere, and ionosphere.

- The troposphere is the region of weather, of decreasing temperature with increasing altitude.
- The stratosphere is a region of relative calm in which temperatures usually remain the same but extremely low.
- The ionosphere is a region which makes radio reception possible.

Motivation

NOTE: Because of the many variations involved, all distances involved in the atmospheric regions should be indicated as being approximate.

Why do airplane pilots prefer to travel very high above the earth?

Duplicate the chart of the atmosphere and distribute to the pupils. Use the chart as a basis for discussion.

Development

1. Elicit the fact that the ocean of air that surrounds the earth is called the atmosphere.
2. Ask the pupils for the weather factors found in the atmosphere. (wind, clouds, rain, lightning, etc.)
3. Using the chart, have the pupils recognize that the layer of air next to the earth's surface is called the troposphere.
4. Question whether any pupils have been in mountainous regions, or are familiar with stories of mountain-climbing. Elicit that the temperature decreases with increasing altitude.
5. Ask the pupils to indicate from the chart the layer of the atmosphere above the troposphere.

5a. From the chart, determine that the troposphere and stratosphere are separated by the tropopause and that the tropopause varies in height.

6. Ask the pupils if they note any indication of weather in the stratosphere.

6a. Indicate that the ozone layer absorbs ultarviolet rays and protects living things from its harmful effects.

7. Develop the concept that the stratosphere is basically a region of "no weather" with little temperature change. Challenge the pupils to answer the question in the motivation.
8. Tell of the relationship between the ionosphere and the reflection of radio waves that makes broadcasting possible.

   NOTE: See motivation for Lesson 3. It is necessary that some materials be prepared one day in advance.

Summary

1. What are the regions of the atmosphere called?
2. Compare the characteristics of the troposphere and stratosphere.
3. In what way is the ionosphere important to man?
4. *What would be the effect upon earth if there were no ozone layer?*

Homework

Complete the table, using *Chart of Atmospheric Regions* (opposite).

REGION	HEIGHT IN MILES	TEMPERATURE	OBJECTS SEEN
	40		
			Meteors
	60-200		
			Top of Mt. Everest
Ionosphere			

3. WHAT CAN WE FIND OUT ABOUT SOME OF THE GASES IN THE AIR?

Outcomes

- About 20% of the air (by volume) is made up of oxygen.
- Carbon dioxide is added to the air by animals and fires.

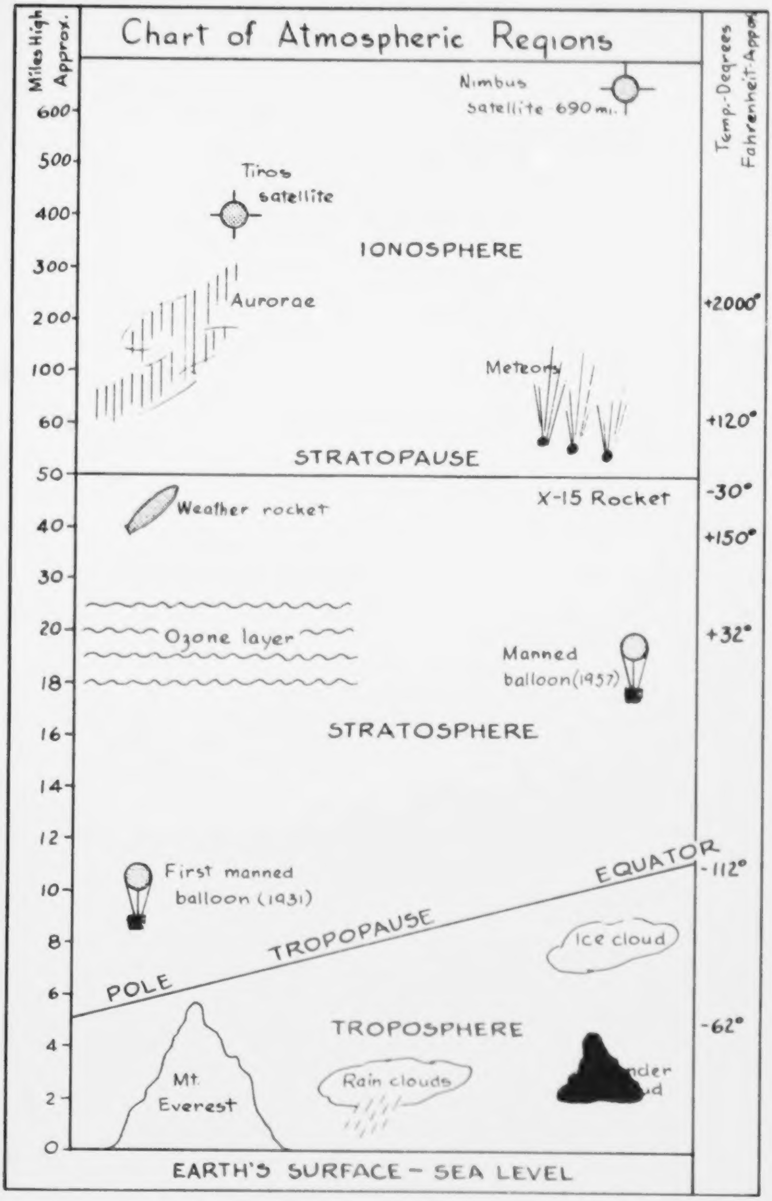


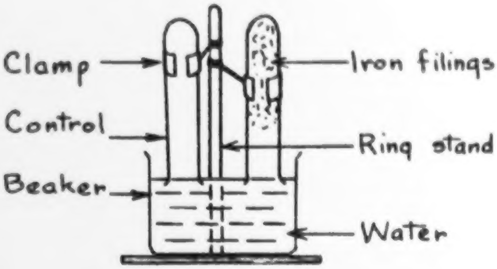
Chart of Atmospheric Regions

Miles High Approx.
Temp.-Degrees Fahrenheit-Approx.
600
500
400
300
200
100
60
50
40
30
20
18
16
14
12
10
8
6
4
2
0
Nimbus satellite 690 mi.
Tiros satellite
IONOSPHERE
Aurorae
+2000°
Meteors
+120°
STRATOPAUSE
X-15 Rocket
-30°
Weather rocket
+150°
Ozone layer
+32°
Manned balloon (1957)
STRATOSPHERE
EQUATOR
-112°
First manned balloon (1931)
TROPOPAUSE
Ice cloud
POLE
TROPOSPHERE
-62°
Mt. Everest
Rain clouds
nder
ud
EARTH'S SURFACE – SEA LEVEL

- Carbon dioxide is heavier than air.
- The amount of carbon dioxide in the air is very little.

Motivation

1. Prepare the materials at least one day before this lesson. Where possible, pupils should observe the preparations.
2. Wet the inside of a test tube or cylinder. Pour out the water. Pour in some iron filings and roll or shake the tube about so that a layer of filings stick to the inside of the glass. Pour out the excess.
3. Next, put the open end of the test tube or glass cylinder into the water, below the surface. Let the water go into the test tube by tilting it a little to make the water level inside the same as the water level outside. Clamp your test tube or cylinder to the ring stand. Do not move it once it is set up.
4. Set up a control with an empty test tube as shown:



5. Show the pupils results of this demonstration. Ask the pupils why they think the water only rose in one test tube. Direct their attention to the iron filings in the test tube. Ask a pupil to note the difference between fresh iron filings and those in the test tube.

Development

1. Elicit that the iron filings in the test tube have rusted. Elicit that uncoated iron rusts when exposed to the air. Point out that rusting iron removes oxygen from the air.

1a. Elicit ways of preventing rusting (such as painting, using oil, and galvanizing). Why are these methods effective?

2. Have the pupils compare the level of the liquids in the test tubes. Elicit that the iron filings used up part of the air.

3. Measure the height of the liquid in the iron filing test tube. Compare this height to the total height of the test tube above the level of water.

   Compute the percentage of oxygen that was used up. This may be done by dividing the total length of the test tube into the height of the liquid in the test tube and multiplying by 100.

   $$\begin{array}{l} \quad\quad\quad\;\; .2 \times 100 = 20\%. \\ \text{Example } 6\,\overline{)\,1.2\quad\quad} \end{array}$$

4. Using a prepared bottle of CO_2 demonstrate the effect of CO_2 on limewater. The pupils should recall this test from grade 7 chemistry.

5. Ask a pupil to hold a burning splint upright with the flame at the upper end of the splint. Pour the contents of a prepared bottle of CO_2 over the burning splint. The pupils should conclude that CO_2 is heavier than air, and that it will put out a fire.

5a. Discuss the chemical changes that take place in breathing and burning. Develop the concept that carbon combines with oxygen to produce CO_2.

6. Have a pupil exhale slowly through a drinking straw placed in a small amount of limewater in a test tube. Have pupils note what happens. Hold a burning splint inside a bottle. Removing the splint, add a small amount of limewater. Stopper the bottle and shake. Pupils should conclude that breathing and burning add CO_2 to the air.

7. Place a small amount of limewater in an empty bottle. Stopper the bottle and shake. The pupils should conclude from the slight cloudiness that because the limewater changes more slowly using air, then the amount of CO_2 present in air must be very small.

8. Elicit that although breathing and fires are always adding CO_2 to the air, the air still contains smaller amounts of CO_2.

Summary

1. How does limewater help us to test for pure CO_2?

2. Is CO_2 heavier or lighter than air? Explain.
3. What gas do animals and fires add to the air?
4. What is the percent of oxygen in the air?
5. What does rusting iron take out of the air?
6. What was the control used in the iron filing demonstration? Why was it used?

Homework

1. Place two iron nails in a bottle one-quarter filled with water. One of these nails should be coated with petroleum jelly or oil. Maintain the level of water. Report to the class at the end of one week.
2. What proof do you have that the air and your breath do not contain pure CO_2?
3. Why should tools be lightly oiled before storing them for a long time?
4. *Encourage reports such as:*
   - *a. the importance and uses of gases such as* O_2, N_2, CO_2, *and* H_2
   - *b.* CO_2 *fire extinguishers*
   - *c. nitrogen cycle*

Materials

Ring stand
Two clamps
Two test tubes
Iron filings
Large beaker
Bottle of CO_2 stoppered
Limewater
Drinking straw
Wood splints
Test tube
Bottle and stopper

4. HOW DOES THE EARTH HEAT THE AIR?

Outcomes

- The source of most of our energy is the sun.

- The earth absorbs and reflects incoming sunlight.
- Absorbed sunlight changes into heat.
- Dark, rough surfaces absorb heat better than light, smooth surfaces.
- The air in contact with the surface of the earth is heated by conduction.

Motivation

Demonstrate a radiometer by placing it in sunlight or exposing it to a lighted incandescent bulb. Have a pupil study the vanes closely and describe the vanes to the class.

Development

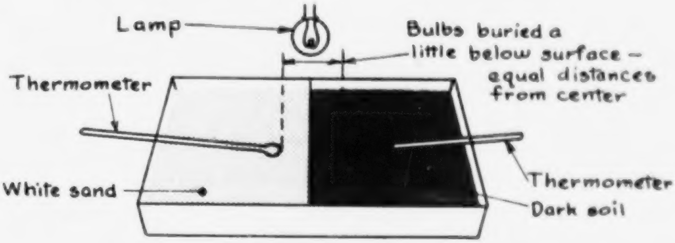
1. Elicit from the class that the dark vane moves away from the light source and the silvered or white vanes move towards the light source. Develop the concept that the dark vane heats up more quickly than the silvered vane. The motion on the dark surface pushes the vane away from the light source.

1a. *Recall from grade 7 that heat is related to the motion of the molecules.*

b. *Relate the fact that the dark vane absorbs more light (heat-energy) which causes greater molecular motion.*

2. Point out that about half of the incoming sunlight which reaches the earth's atmosphere ever reaches the earth's surface. The sunlight that does not reach the earth is either absorbed by the atmosphere, or reflected.

3. Demonstrate the effect of light on dark soil and light sand surfaces. Set up the apparatus as shown. Have a pupil read each ther-


Lamp
Bulbs buried a little below surface — equal distances from center
Thermometer
White sand
Thermometer
Dark soil

mometer before the lamp is lighted. Record the temperatures on the board. Light the lamp. Read the temperatures near the end of the period. Guide the pupils to conclude that dark soil heats up more than light surfaces.

4. Have a number of pupils hold a metal rod in a bunsen flame until it just becomes warm. Encourage pupils to explain why the rod felt warm. Write and define the word *conduction* on the board. Relate the heating of the air in contact with the earth's surface as being heated by conduction.

4a. Since heat involves molecular motion, encourage pupils to speculate what would happen to a length of wire that has been heated.

5. Question the pupils as to which condition would heat the air more — the dark or light soil. From the demonstration, elicit that the dark soil would heat the air more by conduction. Point out that the light sand reflected the light energy better before it could change to heat energy.

Enrichment

If time permits, discuss what happens to the sun's energy as it travels to the earth.

a. Approximately 10% is absorbed by the ionosphere (chiefly in the form of ultraviolet light). Discuss harmful effect of ultraviolet rays and the danger to life if these rays were not absorbed.

b. As sunlight travels further, 35% is reflected by white clouds (compare glare on a white and black surface).

c. Remaining 55% of the sun's energy is absorbed by the earth and re-radiated as infra-red rays by the rocks, soil, and water. Recall infra-red broilers and heat lamps.

Summary

1. How does the earth's surface get its heat?
2. Why do we wear light-colored clothing in the summer?
3. Which of the following would heat up faster?
   beach, forest, snowfield, concrete sidewalk, tar road
4. Why would the air above the soil be warmer than above the sand?

Homework

1. If you have a thermos bottle at home, carefully examine the inside. Explain why the thermos has been coated with a "silver" surface.
2. Why does the beach sand feel hot?

Materials

Radiometer
2 thermometers
Sand
Soil

Lamp and ring stand
Tray and divider
Metal rods

5. *HOW IS THE AIR HEATED?

LABORATORY LESSON

Outcomes

- Heat can be transmitted by conduction and by convection.

Motivation

What would happen if you touched the metal handle of a pot boiling on the stove?

Development

1. Elicit that heat is being transmitted through the handle.
2. Hand out Worksheets and go over them with pupils.
3. Caution the pupils that much of the apparatus will be heated and to exercise caution in handling.
4. Hand out materials and have pupils begin laboratory lesson.

Summary

1. What is the difference between conduction and convection?
2. How does this show how air near the earth is warmed?

---

* Only for classes programmed for five periods.

Homework

1. How is a steam heating system an example of convection?
2. Mention three examples of things at home that pass heat along.
3. Try an experiment at home to show transmission of heat. Write what happened.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 5

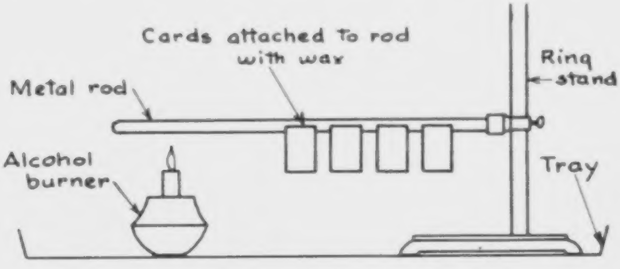
Problem: How is heat transmitted? (passed along)

Materials

5 pieces cardboard, 3" x 3"
Metal rod, 12" long
Ring stand and clamp
Tripod — wire gauze
Candle
Crystals of copper sulfate
Tongs
Asbestos pad
Beaker
Burner and matches

Procedure I

1. Light candle and use dripping wax to attach 4 cards to metal rod.
2. Fix one end of the rod in the clamp attached to the ring stand. Adjust the rod so that the free end is just over the burner.
3. Light the burner and use the flame to heat the free end of the metal rod.



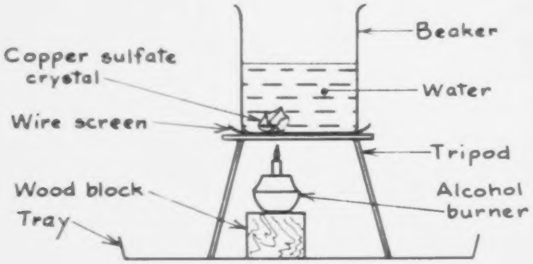
Observations: ______________________________

Conclusions: ______________________________

This is called ______________________________

Procedure II

1. **Fill a beaker with several inches of water and set upon a tripod covered with wire gauze.**
2. **Put a crystal of copper sulfate at inside edge of beaker.**
3. **Place the burner just under the copper sulfate.**
4. **Light the burner.**


Beaker
Copper sulfate crystal
Water
Wire screen
Tripod
Wood block
Alcohol burner
Tray

Observations: ____

Conclusions: ____

This is called ____

Summary

1. Why did the cards fall off the rod in order? ____________________
____
2. How could you prove that the water in the copper sulfate beaker actually circulated? ____
____

6. HOW DOES HEAT TRAVEL THROUGH THE AIR?

Outcomes

- **Air may be heated by convection and radiation.**
- **Heat traveling by means of waves is called radiation.**

- Warm air is lighter than cool air and rises.
- Cold, heavy air replacing warm, light air produces convection currents.

Motivation

Carefully place a bottle filled with moderately hot, dyed water and covered with a glass plate, at the bottom of a large battery jar filled with cool tap water. Remove the glass plate.

Development

1. Elicit from pupils that the dyed water rises to the surface.
2. Use a convection box and by means of smoke paper or "punk" show that the air over the burning candle is rising and the cool air is moving down through the glass chimney.
3. Relate the convection box experience to the convection currents in a liquid. Elicit that when the air around the candle is heated, it expands and becomes lighter, and rises. Conclude that warm air rises and is replaced by the cooler air. This sets up a ***convection current.***
4. To illustrate ***radiation,*** place a glass plate in front of an electric heating coil. Have some pupils note that the light from the coil travels through the glass more readily than the heat.
5. The pupils may recall their experiences when entering closed automobiles in the summertime. Point out that light goes through the glass and is changed to heat when absorbed by materials inside the car. The heat waves are trapped in the car.

5a. Discuss the phenomenon known as the "greenhouse effect." Point out that shortwave light is absorbed by the earth and is changed into heat energy. Carbon dioxide and water vapor in the air are good absorbers of the heat energy. Therefore the heat energy is trapped in the atmosphere. If time permits, diagram the "greenhouse effect" on the board by showing how clouds act as a blanket to trap the re-radiated energy from the earth.

6. Elicit that the air around us is heated by means of convection currents and radiation. Elicit that when the air near the surface of the earth is heated, it rises and is replaced by cooler air.

Summary

1. In what three ways may air be heated?
2. Why does warm air rise?
3. Where would you find the cooler air in your classroom?
4. If you wanted to get proper circulation in your classroom, how would you adjust the windows? Why?

Homework

1. How does a radiator heat your classroom by means of convection currents? Draw a diagram to show the path of the moving air.
2. If you open a refrigerator door, would you feel cold air on your bare feet or your face? Explain.
3. *Why should a radiator be called a convector?*
4. *How does a thermos bottle keep food hot or cold?*

Materials

Bottle
Dyed water
Glass plate
Large battery jar
Convection box
Smoke paper or glowing string
Heating coil

7. WHICH HEATS UP MORE QUICKLY, LAND OR WATER?

LABORATORY LESSON

Outcomes

- Land heats up faster than water.
- Land areas give up their heat faster than water areas.
- Land areas heat largely by conduction.

Motivation

Discuss the pupils' experiences with swimming at the beach. Elicit that the sand gets very hot in the daytime and feels cool at night. Elicit that the water does not seem to have such great temperature differences throughout a day or several days.

Development

Distribute materials to groups of pupils for the laboratory activity. Assist the pupils with the setting up of their materials. A mark placed on the sand thermometer will assure that it is placed at the proper depth — see Worksheet. The sand thermometer should be checked before heating to assure that it is not too close to the bottom of the sand beaker.

Summary

1. After the activity, ask pupils to recall how heat travels through various materials.
2. How did the water in the beaker become heated throughout?
3. How did the sand become heated throughout?

3a. Ask pupils to explain why the temperature continued to rise for a short time after the heat was removed.

4. Discuss the results in the pupil Worksheet.
5. On the basis of this lesson, can you explain why the beach feels hot in the daytime and cool at night?
6. Does the ocean temperature change as quickly as the land temperature? Explain.

6a. Discuss the unequal heating of land and water areas in terms of specific heat.

Homework

1. When will the ocean near New York City have the higher temperature, June 1 or August 1?
2. Fill a small jar with sand or soil and another with water. Replace the caps. Let them set on a table for at least 3 hours. Place both jars on a shelf in the refrigerator. After 1 hour, remove them. Which seems to be colder? Why?

3. *For extra credit plan an experiment (with measurements) to find out which heats up and cools off faster, a solid or a liquid. Write this up. What materials will you need?*

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 7

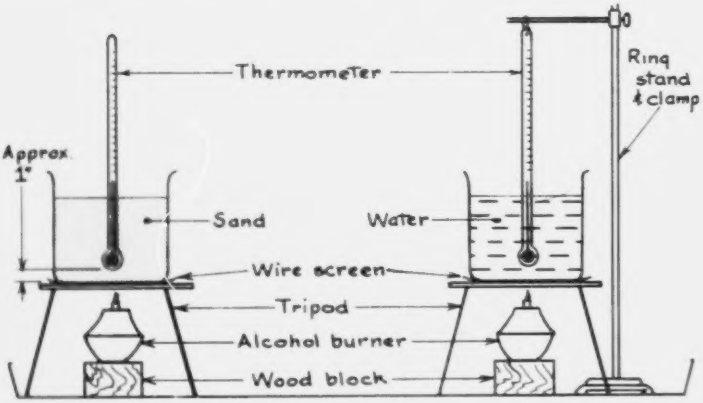
Problem: Do land and water heat up and cool off at different rates?

Materials

Two thermometers
Beaker of sand
Beaker of water
Two tripods
Two alcohol burners
String
Metal tray
Two blocks of wood
Two wire screens
Ring stand
Clamp

Procedure

Set up your materials as shown in the diagram. Make sure you can read your thermometers when placed in the sand or water.



Thermometer
Ring stand & clamp
Approx. 1"
Sand
Water
Wire screen
Tripod
Alcohol burner
Wood block

1. Read each thermometer. Sand ________________° Water ________________°.
2. Light the alcohol burners.
3. At the end of each minute, read the thermometers. Do this for about 7 minutes. Put out the flames by covering them with the metal caps.

NOTE: If the sand thermometer reaches about 150°F before seven minutes are up, put out both flames.

4. Keep a record of each temperature reading on the chart.

5. Continue reading each thermometer after the heat is removed. Do this for about 10—12 minutes. Record the results on the chart.

HEATING		HEAT REMOVED	
SAND	WATER	SAND	WATER
MIN.	TEMPERATURE	TEMPERATURE	MIN.
0			1
1			2
2			3
3			4
4			5
5			6
6			7
7			8
			9
			10
			11
			12

6. a. The sand temperature at the end of heating was ____________________.
   b. The sand temperature at the beginning was ____________________.
   c. The rise in sand temperature (take *b* away from *a*) is ____________________.

7. a. The water temperature at the end of heating was ____________________.
   b. The water temperature at the beginning of heating was ____________________.
   c. The rise in water temperature (take *b* away from *a*) is ____________________.

8. Notice cooling off of sand and water, in "Heat Removed" column.

Questions

1. Which heats up faster, land or water? ____________________.

2. Which cools off faster, land or water? ______________________.

3. What effect would this have on the air above the land or the water?

____

____

8. WHY DOES AIR EXERT PRESSURE?

Outcomes

- Air is matter; it has weight and occupies space.
- Because of its weight, air exerts pressure.
- Air exerts pressure in all directions.
- The pressure of air decreases as the altitude increases.

Motivation

Have a pupil come up and try to push a hard boiled egg (shell removed) through the neck of a milk bottle without crushing the egg. After several unsuccessful attempts, crumple a sheet of paper about 6″ x 6″ into a wad, ignite, insert into the bottle and quickly place egg in neck of bottle.

After the egg has been pushed through, ask the pupils why this happened. Relate the demonstration to the aim (some of the air has left the bottle, thus reducing the pressure inside).

Development

1. Review the definition of matter. Matter is anything that has weight and occupies space.
2. Review that air is made up of elements and compounds, that elements and compounds are forms of matter and have weight.
3. Emphasize that air, as a form of matter, also has weight.
4. Demonstration: Use an equal arm balance to balance 2 collapsed football or basketball bladders.

Fill one bladder with air and replace on balance.

Ask "Which is heavier, and why?"

5. Review the relationship between weight and pressure by using the example of a light, and a heavy body sitting on the pupil.

6. Elicit the fact that we are surrounded on all sides by a sea of air and that the air is exerting pressure in all directions.

7. Demonstration: Fill a tumbler with water. Cover with a piece of cardboard. Invert the tumbler over a pan and remove your hand. Ask why the water remains in the tumbler.

8. Demonstration: Place ½ inch of water in the bottom of a one-gallon can. Heat the open can until the water boils and the steam is coming out.

   CAUTION: Quickly remove can from flame and cap tightly. Allow the can to stand. Observe results. (For faster results, the can is cooled with cold water). Ask why the can collapsed.

9. Pile blocks or books upon each other. Elicit that the total weight increases as the number of blocks increase.

10. Compare a block of wood with a "block" of air. Tell them that a "block" of air one cubic foot weighs 1¼ ounces.

11. By analogy, build up a pile of "blocks" of air and develop that as the height of the pile increases, the weight or pressures of the air increases.

12. Tell pupils that the total weight of a column of air one square inch in base area is equal to 14.7 (approximately 15) pounds at sea level. This is what is meant by air pressure.

13. Develop that the higher you are in the atmosphere the fewer the number of air molecules are present. Therefore, the weight and pressure is less.

13a. Review density. State that the pressure of one atmosphere is equal to a column of water 34 feet high. Tell that mercury is 13.6 times heavier than water. Ask pupils to calculate height of column of mercury equal to one atmosphere.

$13.6\overline{)\,34}$ equals 2.5 feet or approximately 30 inches.

Summary

1. Why didn't the water in the tumbler spill out?
2. Explain why air pressure is greater at sea level than on a mountain top.
3. Compare the pressure at sea level and at the bottom of a very deep mine.

Homework

1. How much pressure is air exerting on one square foot?
2. Why doesn't the great pressure of air crush your chest?
3. Why is the air pressure in Denver, Colorado (the mile high city) normally lower than the air pressure in New York City?

Materials

Hard boiled egg
Milk bottle
Burner
Tumbler
Tripod
Square of cardboard to cover tumbler
One gallon can with cover
Football or basketball bladder
Equal arm balance
Air pump

9. WHAT CAUSES CHANGES IN AIR PRESSURE?

Outcomes

- Heated air is lighter than cool air.
- Moist air is lighter than dry air.
- Dry, cool air produces regions of high pressure.
- Warm, moist air produces regions of low pressure.

Motivation

1. Place a gallon tin on an equal arm balance scale. Add enough weight to the other side to balance the scale.

2. Heat the sides of the tin can with a hot bunsen burner flame for about one minute. Do not touch the tin can. Hold the scale still and gently release.

Development

1. Elicit from the pupils that the tin can has moved upwards and that it must have gotten lighter.

2. Develop the concept that the heated air expanded and some of it escaped from the opening in the can. Point out that there is less air in the can so that the can becomes lighter.

2a. Relate this to Grade 7 Physics unit on heat — heated objects have increased molecular motion which causes distance to expand.

3. As the can cools it sinks downward. Elicit that the can is getting heavier. Why?

4. A brief discussion of the first balloon flights, using hot air, will help the pupils to better understand that heated air is relatively light. Hot air ballooning is actively engaged in as a sport nowadays.

5. Elicit that an equal amount (volume) of warm air is lighter than an equal amount of cool air.

6. Ask the pupils which they think is lighter, moist or dry air at the same temperature. Point out that moist air is lighter.

7. Draw a large circle on the board to represent the earth. Label the Equator and the North Pole. Ask the pupils where they would expect to find the heaviest and lightest air on the earth. Elicit that the poles are very cold and the air must be quite heavy. Point out that regions where the air is relatively heavy are called *highs* or *high pressure regions.*

8. Have pupils draw a circle *representing the earth* in their notebooks. Have them label the polar highs and the equatorial low. Show the locations of other highs and lows to add to drawings.

8a. Develop the formation of the world pressure belts. Include variations that take place in the winter and summer. Include the effects of large land and sea areas on air pressure.

9. Elicit that the equatorial region is hot and should be an area of low pressure.

Summary

1. Why does heated air become lighter?
2. How does moisture affect air pressure?
3. Which is heavier — cool, dry air or warm, moist air?
4. Which is heavier — cool, dry air or cool, moist air?

Homework

1. Next to each of the following, write whether it will be a region of high pressure or low pressure.
   - a. South Pole
   - b. North Pole
   - c. Equator
   - d. Gulf of Mexico
   - e. Desert in Africa
2. When is the air heavier, on a very cold winter day or on a hot muggy summer day?
3. *Prepare a chart showing the location of the world pressure belts.*

Materials

Equal arm balance

Gallon tin

Bunsen burner

10. *WHAT CAN WE LEARN ABOUT AIR PRESSURE?

LABORATORY LESSON

Outcomes

- Air is matter and occupies space.
- Air has weight.
- Because of its weight, air exerts pressure.
- Air pressure is exerted in all directions.

Motivation

1. Place a thin, narrow stick — about 2′ x 1″ x ¼″ — on the demon-

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* Only for classes programmed for five periods.

stration table with about 8″ extending out from the table. Place a few sheets of newspaper over the part of the stick on the demonstration table.

2. Tell the pupils that you are going to try to break the extended stick without holding the opposite end down.
3. Strike the extended part sharply with the edge of a heavy ruler.

   CAUTION: The extended part of the stick should face away from the class.

Development

1. Elicit from the pupils that the sheets of newspaper did not have enough weight to hold the stick down. Point out that something must have held the paper down. Lead the pupils to suggest that the air above the newspaper had enough force to hold it in place. Elicit that the air pressure held the paper down.
2. Recall the force of air pressure by referring to the crushing of the tin can.
3. Distribute Worksheets and materials. Read and discuss the directives. Guide the pupils in procedures.

Summary

Discuss the laboratory activities and the accompanying questions on the Worksheet. Have the pupils recall from previous lessons on air pressure that the weight of air above the earth is the cause of air pressure.

Homework

1. How did we show that air occupies space?
2. How did we show that air has weight?
3. Which activity showed that air exerts pressure in many directions?

Materials

Stick about 2 ft. x 1″ x ¼″	Heavy ruler
Sheets of newspaper	

NOTE: For the laboratory work, ask pupils to bring in empty plastic containers (with stoppers) such as Clorox, etc.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 10

Problem: Does air have weight and exert pressure?

Material

Plastic bottle (large) with stopper
Triple beam balance
8 inch test tube
2 x 2 square of cardboard
Battery jar or large pan

Procedure I

1. Balance your triple beam balance at zero.
2. Weigh the container and stopper.
3. One student should take the container and step on it to flatten it as much as possible.
4. Another student should plug the flattened container as tightly as possible.
5. Weigh the flattened container.

Observations:

1. The bottle contained ____________________ at the start.
2. The container, stopper and air weighed ____________________ grams.
3. The container and stopper when flattened weighed ____________________ grams.
4. This (loss) (gain) ____________________ of weight of ____________________ grams is due to the weight of the ____________________ that was forced out.

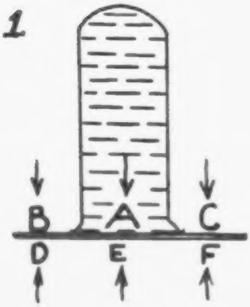
Procedure II

1. Fill the test tube to the top with water.
2. Slide the cardboard across the mouth of the test tube and hold it on tightly.
3. Turn the test tube over while holding the cardboard.
4. Holding the test tube over the battery jar or pan carefully move your hand away from the cardboard.
5. Carefully turn the test tube sideways.

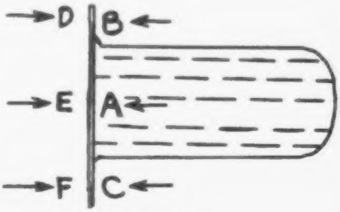
Observations:

1. The cardboard (falls) (does not fall) ______________ from the test tube.
2. Using the diagram, tell what pressures are trying to push the cardboard down or hold it in place.
   a. At point A______________.
   b. At points B and C______________.
   c. At points D, E, F______________.

1



2.



3. The upward______________of air at points D, E, and F held the card to the test tube. (See #1)
4. The sideward push at D, E, F is (more, less) than that at A, B, C. (See #2)______________.

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11. HOW ARE WINDS FORMED?

Outcomes

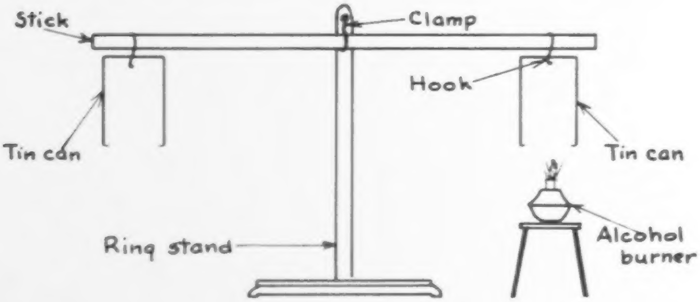
- A horizontal movement of air is called a wind.
- A vertical movement of air is called an air current.
- Air moves from regions of high to low pressure.
- Differences in pressure cause air to move at different speeds.

Motivation

Ask pupils where they spend their summers. Elicit the fact that many leave the hot city for cooler areas. Elicit also, that in the winter some people go to Florida because it is warmer.

Development

1. From the motivation develop that the temperature of the surface and the air above, at any given time, is not the same in different areas of the earth.
2. Perform the following demonstration:



Have the pupils conclude that warm air is lighter than cold air.

3. Fill two small balloons (of the same size) with air. One should contain much more air than the other. The pupils should note this as they observe the filling of each balloon.
4. Elicit from the pupils that the balloon holding more air has a greater pressure. Have pupils recall how the weight of air above the earth causes air pressure on the surface.
5. Direct a stream of air from each balloon at a candle flame.

5a. Develop that as the wind moves above the obstructions on the surface, its speed increases with altitude.

6. Develop the idea that the air with the greater pressure moved more quickly. Elicit that the greater the air pressure difference between two places the faster the air moves. Point out that the greater the difference in pressure between a high and a low the faster the wind blows.

6a. Ask if any pupil knows what the jet stream is. Tell about the easterly flow of very fast winds high in the atmosphere in our *latitudes that profoundly affect our weather. Mention the theory that the jet stream wards off hurricanes from our area.*

7. Elicit from the pupils that "cold air-high pressure" always tries to fill in "warm air-low pressure" areas. Identify the filling-in as a horizontal movement of air or wind.
8. Have the pupils recall that in convection, warm air rises and cold air sinks. Identify this vertical movement of air as air currents.
9. Identify winds by the direction they are coming from. A north wind blows from the north, a southwest wind blows from the southwest, etc.

Summary

1. Under what conditions will a wind form?
2. What causes the air to move faster?
3. What is the difference between a wind and an air current?
4. In what direction does a south wind blow? a north wind?

Homework

1. How is a wind started?
2. Why are some winds stronger than others?
3. *Why is the airplane trip from California to New York faster than from New York to California?*

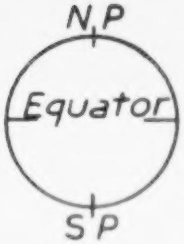
12. HOW DOES THE AIR CIRCULATE AROUND THE WORLD?

Outcomes

- The world is a huge convection system.
- The rotation of the earth causes moving air to change direction.
- The patterns of the movement of air have greatly affected the climate, appearance and history of the earth.

Motivation

Draw this diagram on the chalkboard:



Ask pupils where on this globe would the winds start?

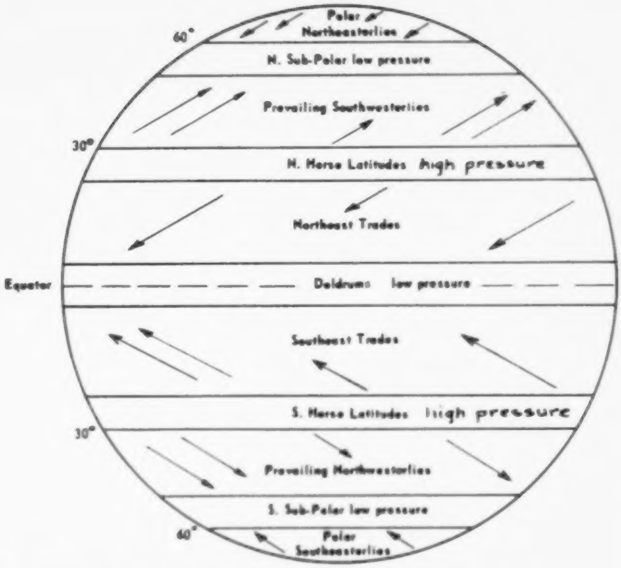
Development

1. Elicit that the equator is a region of high temperature, and the poles are regions of low temperature.
2. Recall the lesson on convection, and develop that at the equator the warm air will rise and the cooler air from the poles will flow in to take its place.
3. Have the pupils point out that the movement of cool air (winds) will be both from the north and south toward the equator.
4. Drop water on the top of
   a. stationary globe and then
   b. on a rotating globe (turning counterclockwise) and have the pupils compare the stream of the water on the globe.
5. Relate the flow of the water to that of the air and develop the concept that because of the rotation of the earth, winds which are blowing from the north and from the south are deflected to the east and west.

   In the northern hemisphere the winds are deflected to the right and in the southern hemisphere the winds are deflected to the left.
6. Prepare a transparency or chalkboard diagram of the wind system on a rotating globe. Discuss this. (See next page.)

6a. Explain the deflection by referring to Ferrel's Laws showing the relationship of the speeds of the winds as compared to the speed of the rotating earth at different points.

7. Elicit from the class some ways in which man and the earth have been affected by the wind system. Some examples are:
   a. The spread of early civilization because of Trade Winds.


Poler Northeasterlies
60°
N. Sub-Polar low pressure
Prevailing Southwesterlies
30°
N. Horse Latitudes high pressure
Northeast Trades
Equator
Doldrums low pressure
Southeast Trades
S. Horse Latitudes high pressure
30°
Prevailing Northwesterlies
S. Sub-Polar low pressure
60°
Polar Southeasterlies

b. Formation of deserts in regions of Horse Latitudes.
c. Differences of climate on the opposite sides of a continent.

8. *With the aid of the chart, develop the formation of a convection system between the Equator and the Horse Latitudes.*

Summary

1. Why does a convection current form between the equator and the poles?
2. Why don't all winds blow north and south?

Homework

1. Why is the equator a region of light winds?
2. Why are winds deflected?
3. Tell two ways in which man has been affected by the global wind system.
4. *What might happen to a wind that crossed the equator from the north?*

Materials

Globe
Medicine dropper
Beaker

13. WHAT CAUSES SOME LOCAL WINDS?

Outcomes

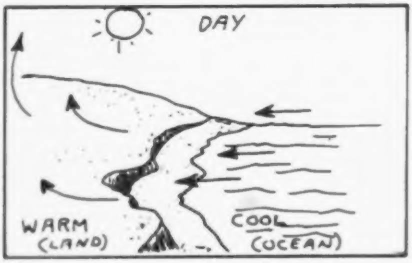
- Special winds are usually local winds.
- Sea breezes occur during daytime.
- Land breezes occur during nighttime.
- Monsoon winds occur on a seasonal basis.

Motivation

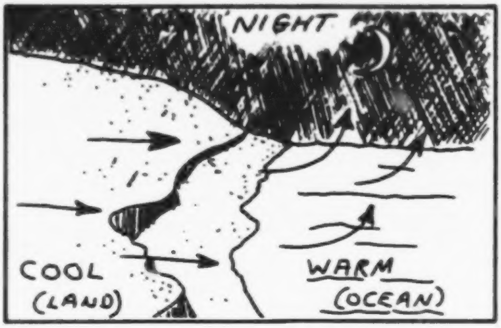
Why is there usually a breeze at the beach in the summertime?

Development

1. Have the pupils recall from the lesson on "How the earth heats the air" that the land heats up faster than the sea in the daytime.
2. Recall the fact that the air over the land is lighter and the pressure less than the air over the sea.
3. Elicit from the pupils that a convectional system has been set up between the land and sea with the breeze blowing in from the ocean. Why?
4. Tell the pupils that the breezes are named for their source and identify the breeze as a sea breeze. Have them copy diagram.



5. Go through the same process for the nighttime eliciting these facts:
   a. land cools off faster than water
   b. air over land is cooler and the pressure greater than the air over sea
   c. wind will now blow from the land to sea
   d. this type of breeze is called a land breeze



5a. Apply reasoning to valley and mountain breezes.

6. Refer to a world map or globe. Elicit from the pupils that in the regions near the equator there is little daily temperature change in both land and sea. Develop the fact that the sea and land maintain the same relative pressures.

7. Developing the idea that temperatures north and south of the Equator are different from that of the Equator, guide the pupils to conclude that the convectional system is now on a seasonal rather than on a daily basis.

8. Have the pupils develop the direction of wind during the summer and winter. Draw this roughly on the chalkboard.
   Identify the monsoon as this type of seasonal wind.

Summary

1. Why does a sea breeze usually blow during the daytime?
2. How does a sea breeze differ from a monsoon wind?
3. Why are the special winds usually local in nature?

Homework

1. When does a sea breeze change to a land breeze?
2. Why is a sea breeze a local breeze?
3. What would be the effect of both the land and the sea being at the same temperature?
4. *What would happen if the land did not cool off at night?*

NOTE: In preparation for the next lesson, place a plastic bag over the leaves of a potted plant (see Lesson 14).

14. HOW DOES WATER GET INTO THE ATMOSPHERE?

Outcomes

- Water vapor is formed by the evaporation of water.
- The oceans are the main source of water vapor in the air.
- Plants, animals, and fires add water vapor to the air.
- Heat and air movement are important factors in the rate of evaporation.

Motivation

Carefully place a burner flame (or a burning splint) close to the chalkboard. Use the flame to write H_2O on the board.

Development

1. Lead the pupils to conclude that fires produce water vapor.
2. Have the pupils recall that breathing adds moisture to the air. Briefly demonstrate by breathing against the chalkboard.
3. On the preceding day place a plastic bag over the leaves of a potted plant. Tie the bag around the lowest part of the stem. Have the pupils observe the water droplets on the inside surface of the plastic bag. Cover another section of the plant with a dry plastic bag. The pupils should note that it is still dry shortly after it has been applied. Point out that the plant removed water from the soil and gave it up to the air through the leaves.

3a. *Develop idea of plant transpiration. Elicit how the leaf controls the amount of water allowed to evaporate — stomates, etc.*

4. Moisten an ordinary blotter, evenly. Cut it in half. Attach each half to opposite ends of a stick that has been suspended horizontally from a clamp on a ring stand. Balance the stick. Place a 100W lamp close to one of the blotter halves. Have the pupils suggest what is going to happen. This will take a few minutes. Return to it near the end of the lesson.

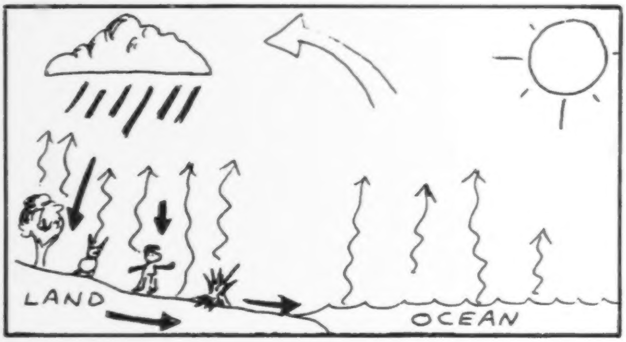
5. Moisten two sections of the chalkboard. Have one pupil fan one area with a large cardboard. The pupils should point out that moving air speeds up evaporation.

5a. *Discuss molecular motion and how it affects evaporation. Point out that even ice evaporates, but at a much slower rate.*

6. Show the pupils a large map of the world. The pupils should note that there is much more water area than land area. Point out that about 75% of the earth's surface is covered with water. Elicit that the largest source of water for the air is the oceans.

6a. *Elicit the parts of the earth's atmosphere that should have the largest moisture content. The moisture content of soil, large numbers of plants, large ocean areas, and the heat make the equatorial air the "wettest" (highest moisture content).*

7. Draw a simple diagram of the water cycle on the board. Have the pupils note how water returns to the air from bodies of water, plants, animals and fires.



Summary

1. On what kind of day does perspiration evaporate most quickly?
2. What are the various sources of water vapor for the atmosphere?
3. Where does most of the water in the air come from?

Homework

1. How do clothes driers (machines) dry wet wash so quickly?
2. Name five things that add water vapor to the air.
3. *Design an experiment showing how surface area affects the rate of evaporation.*

Materials

Bunsen burner (or wood splint)
Plastic bags
Potted plant
String
World map
100W bulb and wired socket
Ring stand
Clamp
Blotter (about 3" x 8")
Yard- or meterstick
Cardboard

15. *HOW CAN WE SPEED UP THE EVAPORATION OF WATER?

LABORATORY LESSON

Outcomes

- The movement of air speeds up evaporation.
- Heating a body of water speeds up evaporation.
- Water evaporates more quickly if we increase its surface area.

Motivation

1. Show the pupils two test tubes ½ filled with water.
2. Ask the pupils how long they think it would take for the water to evaporate from the test tubes if they were left standing in a rack.

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* Only for classes programmed for five periods

3. Soak a paper towel with water from one test tube. Wipe the towel across the board. Keep adding water until the test tube is empty. Tack the paper toweling to a cork board.
4. Tell the pupils that they will compare the amount of evaporation of the two quantities of water, later in the period.

Development

1. Show the pupils a prepared strip of blotting or filter paper that has been soaked in cobalt chloride solution and allowed to dry. Cobalt chloride solution is prepared by dissolving a few large crystals of cobalt chloride in a small beaker of warm water.
2. Demonstrate how cobalt chloride acts as a moisture indicator.
3. Distribute Worksheets and materials. Read the Worksheets along with the pupils to help them better understand the activities.
4. When the chalkboard and paper toweling are practically dry, compare the amount of evaporation that has taken place between the two original amounts of water. Elicit that spreading out water or increasing its surface area speeds up evaporation.

Summary

Relating to the pupils' experiences with the rate of drying as determined by heat and air movement, ask "What three methods can speed up evaporation?"

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 15

Problem: How can we speed up the evaporation of water?

Materials

5 strips of cobalt chloride paper
  2" x ½"
Beaker of warm water
Beaker of cold water
Alcohol burner
Paper toweling
Test tube holder
Test tube — pyrex only

Procedure

1. Hold one strip of paper over the warm water and another over the cold water.
   - a. The strip over the warm water ____________________.
   - b. The strip over the cold water ____________________.
   - c. Warm water evaporates (faster, slower) ____________________ than cold water.
2. Dip two strips into the cold water. Place one strip inside a pyrex test tube. Gently heat the test tube by moving it back and forth in an alcohol burner flame.
   - a. Both strips turned ____________________ when wet with water.
   - b. The strip in the test tube dried out (slower, faster) ____________________ than the strip on the desk.
   - c. Evaporation is speeded up by ____________________.
3. Wet one strip by pressing it against a soaked piece of paper toweling. Tear the strip in half. Place one strip on the desk. Wave the other strip back and forth for a few minutes.
   - a. The strip on the desk dried up (slower, faster) ____________________ than the waved strip.
   - b. Evaporation speeds up on (calm, windy) ____________________ days.

Homework

Take home your cobalt chloride strip. Use it outside your window for one week. Use the chart to keep your record of humidity each day.

	Moist (pink)	Dry (blue)	Outside Weather
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

16. WHAT IS MEANT BY THE HUMIDITY OF THE AIR?

LABORATORY LESSON

Outcomes

- Warm air holds more moisture than cold air.
- The amount of moisture the air can hold increases with temperature.
- The dew point is the temperature at which humidity is 100%.
- The percent of moisture in the air is called the relative humidity.

Motivation

What is meant by the saying "It's not the heat, it's the humidity?"

Development

1. Using a medicine dropper, place several drops of water into a large flask. Stopper the flask with a cork. Heat the flask gently until the water evaporates.
2. Elicit from the pupils that the water in the flask must still be in the flask but in the form of water vapor.
3. Explain that the percent of moisture in the air is called the ***relative humidity.***
4. Ask "What would happen if we cooled the flask?" Elicit from the pupils that as the flask cooled some of the water vapor would appear in a liquid form. Conclude that as temperature increases, the air can hold more water. As temperature decreases it holds less.
5. Develop the idea that at any given temperature there is a maximum amount of water vapor that the air can hold. This is called the ***dew point.***
6. Distribute materials and have the pupils begin the laboratory work. Tell the pupils before they start to fill a beaker with some water and to let it stand until needed.

Summary

1. What condition does the dew point indicate?
2. How can you make the condensed moisture evaporate?

Materials

Large flask
Cork for flask
Burner
Medicine dropper
Beaker

Enrichment

1. *Elicit that the volume of a container is called capacity. Develop that the amount of moisture the air can hold at any given temperature is its capacity.*
2. *Elicit that the air is not always full of moisture. Explain to the class that the actual amount of moisture in the air is called the absolute humidity.*
3. *Introduce a number of problems which show that the percent of moisture in the air can be expressed as a ratio between the absolute humidity (part) to the capacity (whole).*

$$\%\ \text{Relative Humidity} = \frac{\text{absolute humidity}}{\text{capacity}} \times 100$$

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 16

Problem: What is the dew point and relative humidity in the classroom?

Materials

2 shiny metal cans
Glass stirring rod
Ice cubes
Relative humidity chart
Cheesecloth
Rubber band
2 thermometers
Beaker

Procedure I

1. Half fill one metal can with ice cubes and water, the other with plain tap water.
2. Stir the water gently with a glass rod.
3. Insert a thermometer in each can.
4. Stand the other metal can away from the first can.

Observations:

1. Record the room temperature________________________.
2. What do you observe on the outside of the tap water can? ________________________
3. Observe the water-ice can carefully. Compare it to the other can of tap water. Record the temperature of the water in the can with ice cubes when you first see a mist or water form on the outside of the can.

Conclusions:

1. When water is cooled and condenses on objects, it is called dew. The temperature at which water condensed on the can was ________________________degrees.
2. The dew point of the air in this room is________________________ degrees.
3. If the air in the room is very moist (humid), water should collect on the can at a (higher, lower)________________________temperature.
4. When the air temperature and dew point are about the same, the air should be very (dry, humid)________________________.
5. Rain or fog are most likely to occur when the dew point temperature and air temperature are (close together, far apart)________________________.

Procedure

1. Observe the air temperature and record as the Dry-bulb temperature.
2. Wrap a piece of cheese cloth around the bulb of a thermometer and fasten it with a rubber band.
3. Dip the cloth into the water of the beaker which had been left standing. (This should now be at room temperature.)
4. Fan the cloth vigorously until the temperature no longer decreases. Record this temperature as the Wet-bulb temperature.
5. After you have filled in your observations, use the relative humidity chart to determine the relative humidity.

Observations:

1. Dry bulb temperature________________________
2. Wet bulb temperature________________________
3. Difference between 1 and 2________________________

Conclusion:

The relative humidity in the classroom is________________________percent.

Homework

1. Where did the water droplets on the can come from?
2. What is humidity?
3. How does temperature affect the amount of moisture the air can hold?

RELATIVE HUMIDITY IN PERCENT

Dry-Bulb Temp.	Difference in degrees between wet-bulb and dry-bulb thermometers									
	1	2	3	4	5	6	7	8	9	10
68°	95	90	85	81	76	72	67	63	59	55
70°	95	90	86	81	77	72	68	64	60	56
72°	95	91	86	82	78	73	69	65	61	57
74°	95	91	86	82	78	74	70	66	62	58
76°	96	91	87	83	78	74	70	67	63	59
78°	96	91	87	83	79	75	71	67	64	60
80°	96	91	87	83	79	76	72	68	64	61
82°	96	91	87	83	79	76	72	69	65	62

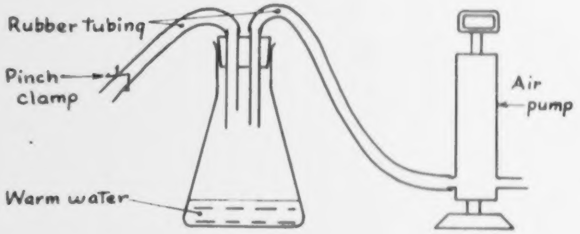
17. HOW ARE CLOUDS FORMED?

Outcomes

- Clouds and fogs form when air is cooled below its dew point.
- Dust particles in the air form centers around which water droplets can collect to form clouds.
- Clouds are identified by their appearance (stratus, cumulus, cirrus, and nimbostratus).

Motivation

1. Set up the apparatus:



2. Pump a small amount of air into the flask.

3. Release the pinch clamp.

Development

1. The pupils should note that a faint cloud appeared in the flask.

2. Remove the rubber stopper. Add smoke to the flask (this may be done by dropping a burning match into the flask). Replace the stopper.

3. Repeat steps 1-3 of motivation.

4. Have the pupils observe that tiny particles in the air aid in the formation of a cloud.

5. Have pupils recall the dew point experiment they did in the laboratory on humidity. Elicit that cooling causes water vapor to *condense* from the air when it reaches the dew point.

5a. Have pupils explain dew on the glass of a cold drink or the frost on refrigerator pipes in terms of the dew point.

6. Point out that the air that was compressed in the flask cooled when it expanded and escaped through the pinch clamp.

7. If available, show the pupils a CO_2 cartridge used for racing cars. Ask them what would happen if the compressed gas inside suddenly escaped. Demonstrate, by puncturing the cylinder, that the cylinder becomes very cold. A release of pressure cools air.

8. Relate this to rising air expanding and cooling. Elicit that clouds may be formed in this way. When water vapor cools into water droplets, they collect around particles of dust or smoke.

9. Elicit that air near the ground also loses heat by conduction to cooler surfaces. The cooled moisture in the air condenses and visible fog is formed near the ground.

9a. Discuss radiation and advection fogs. Point out that radiation fogs occur when the earth loses heat by radiation into clear skies. The air near the earth's surface cools and condenses. Advection fogs are formed when moist air traveling over a cold surface condenses.

10. Show pictures of three common clouds. Identify the "puffy" or billowy clouds as cumulus, and the somewhat layered clouds as stratus. The very light feathery cirrus clouds are found miles above the earth (at least 20,000 ft.).

10a. Discuss the nomenclature of clouds. Teach terms such as cirrostratus, altocumulus, altostratus, and cumulonimbus.

11. Tell pupils that rain or snow clouds are called nimbostratus.

Summary

1. How does cooling produce clouds and fogs?
2. In what two ways can the air be cooled?
3. How are clouds different from fogs?
4. Name 3 kinds of clouds and describe each briefly.

Homework

1. Keep a record of the various cloud forms you see in the sky in one week. Observations should be made about 8:00 A.M. each day. Use the chart to record your observations.

Type of Cloud			
Day	Stratus	Cumulus	Cirrus

1a. Make a chart showing the various cloud types and their heights as reported in the weather reports of a newspaper. Correlate this with the type of weather we will have (rain, fog, etc.).

2. Draw pictures of stratus, cumulus, and cirrus clouds.

Materials

- Erlenmeyer flask (large)
- Two-hole rubber stopper
- Glass tubing
- Rubber tubing
- Pinch clamp
- Warm water
- Air pump
- Matches
- CO_2 cartridge

18. HOW IS WATER RETURNED FROM THE ATMOSPHERE?

Outcomes

- Water droplets, condensed around dust and other particles forming clouds, will grow into larger drops.
- When the droplets in a cloud become heavy enough, they fall to the ground.
- Precipitation appears in the form of rain, sleet, snow, and hail.
- A rain gauge and ruler are used to measure precipitation.
- *Artificial means may be used to cause rain.*

Motivation

Show pupils a globule of mercury. Break the globule into many small bits and then push them together again. Ask the pupils if they see any relationship in the formation of rain.

Development

1. Recall the lesson on clouds, and that the droplets of moisture are too light to fall as rain.
2. Explain that the droplets in the cloud are in motion and are colliding with each other.
3. Guide the pupils to the understanding that in colliding, the water droplets merge with each other and become heavy enough to fall as rain.
4. Recall the fact that many types of impurities, such as dust, pollen, industrial wastes, salt crystals, etc., may be found in the air.

5. Develop the concept that these impurities will collect enough water to make them heavy enough to fall as rain. Tell pupils that rain and snow are called *precipitation.*

6. Ask the pupils to suggest as many other forms of precipitation as they know. Write these on the chalkboard.

7. Develop the formation of

   a. sleet as rain which passes through a freezing layer of the atmosphere and turns to ice.

7a. Discuss the differences between dew and rain; and snow and frost.

   b. snow as frozen water vapor (water vapor changes directly into snow).

   c. hail (frozen rain) as being the result of bouncing around in convectional currents and adding more layers during this process. Indicate that hail is generally associated with thunderstorms.

7b. Ask the pupils what would happen if rain hit the ground and froze rapidly. Identify this phenomena as glaze. Discuss the destructive damage done by these ice storms.

8. Discuss man's attempts to make rain. Develop the methods of artificial rain-making. Compare the use of silver iodide (as nuclei around which the moisture will condense) to the release of carbon dioxide pellets (which cause the formation of ice crystals which help the cloud to precipitate its moisture).

9. Show the pupils a *rain gauge.* Explain that this is used to measure amount of rainfall.

9a. Elicit from the pupils that ten inches of snow are needed to make an inch of rain. Explain how a rain gauge is used to collect and measure precipitation.

Summary

1. What is precipitation?

2. What factors are necessary for precipitation to occur?

3. Compare natural to artificial rain-making.

Homework

1. **Explain how rain changes to sleet.**
2. **How does rain differ from dew?**
3. **What is the difference between sleet and snow?**
4. ***Elicit why it can rain in the upper atmosphere and not on the ground.***

WEATHER

Suggested Lessons and Procedures

19. WHO CARES ABOUT THE WEATHER?

Outcomes

- People and industry are greatly affected by the weather.
- The weather factors are temperature, humidity, precipitation, sky condition, winds and air pressure.
- A station model is a convenient way of showing these weather factors.

Motivation

Relate the following: "You have planned to go to the beach or to a game with your friends. What is the first thing you look for when you get up in the morning?"

Development

1. Develop a list of weather factors on the chalkboard that will include temperature, humidity, precipitation, sky condition, wind, and pressure.
2. Ask, "Who cares about the weather?" Elicit from the pupils the effect of weather upon
   a. themselves and their families
   b. a resort hotel or summer camp
   c. a clothing store

d. farmers

e. a utility company (ex. lighting)

3. Ask, "If you heard a weather report from Chicago, would it be important to you now?"

3a. Distinguish between weather and climate.

a. Weather refers to a particular locality.

b. Weather is usually limited to a comparatively short space of time.

c. Climate involves a long period of time and refers to a large area.

4. Elicit from the pupils some reasons why they might be interested in the weather in other parts of the country.

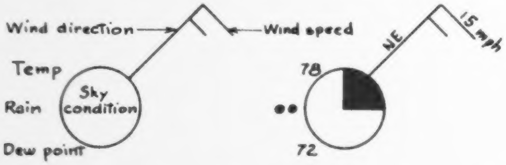
5. Ask the pupils where they could find this information. Develop the conclusion that the only place they could find this information would be on a weather map of the country.

6. Show the pupils an official weather map put out by the Weather Bureau or a weather map clipped from a newspaper. Elicit from the pupils that it would not be practical to write all the weather factors for all the cities shown.

7. Elicit the need for a system of notation that could show in a very compact form all necessary information that would give a good description of the weather in any locality.

8. Draw a *station model* on the chalkboard. Put in the sky condition, wind direction, wind speed, temperature, dew point, pressure and precipitation.

8a. Consult New York Times. What is the Beaufort scale? Relate to wind velocity. Compare knots to miles per hour.



9. Ask the pupils if the station model has any meaning for them. Elicit the fact that it has been designed to give information to anyone who understands the chart.

10. **Lead them step by step to an explanation of all the notations in the station model.**
11. **List this information on the chalkboard.**

	ALBANY	WASHINGTON
Temperature	55°	70°
Air pressure	1012	1004
Dew point	51	66
Wind direction	NW	SE
Wind speed	10	5
Sky condition	Clear	Cloudy
Precipitation	none	.1

Ask the class to construct a station model for Albany. When they have finished, go over this in class.

12. **Tell the class that a station model may contain many other items of weather information but that these are the most common.**

12a. Develop other weather information in the station model such as visibility, present weather, cloud heights and barometric change and tendency.

+ means rising pressure ***— means falling pressure***

Summary

1. **What is weather?**
2. **Why is weather important?**
3. **What is a station model?**

Homework

1. **List the weather factors.**
2. **Tell why the weather may be important to you in the next few days.**
3. **Make a station model for Washington from the information given to you by your teacher.**

Materials

Weather map

20. *HOW CAN WE MAKE A CLOUD AND FOG IN THE LABORATORY?

LABORATORY LESSON

Outcomes

- Dust in the air is needed to form clouds.
- When air cools below its dew point, clouds and fogs form.
- Rising air expands and cools.

Motivation

Why do we see our breath in the wintertime?

Development

1. Elicit from the pupils that their warm breath contains water vapor. In the wintertime, the breathed-out air is cooled to its dew point by the cold outside air and the breath is seen as a cloud or fog.
2. Tell the pupils, as an application to what they have learned, that they are going to make clouds and fogs in bottles.
3. Distribute Worksheets and materials. Assist the pupils with the reading and understanding of the activities.
4. After the pupils do the simple laboratory activities, show them pictures of clouds. A filmstrip projector or the opaque projector may be used as well.
5. Have the pupils identify the clouds shown by using the terms stratus, cumulus, cirrus, and nimbostratus.

Summary

1. What was added to the cloud bottle to make a thicker cloud appear?
2. What has to happen to the air for fog or clouds to form?
3. What do we always find in the air that water vapor can cling to and form clouds?

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* Only for classes programmed for five periods

4. **Draw stratus, cumulus, and cirrus clouds on the board. Have the pupils recall the names of the clouds.**

5. **What do we call rain or snow clouds?**

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 20

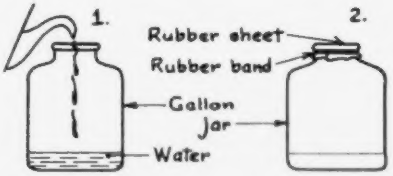
Problem: How can we make a cloud or fog in a bottle?

Materials ACTIVITY I.

Matches
Gallon jar
Small beaker of water
Heavy rubber band
Rubber sheet

Procedure

1. Set up the materials as shown:



2. After the rubber sheet has been attached to the jar, turn the jar sideways. Slowly turn the jar to spread out the water.
3. Move the sheet up and down a few times.

Observations: ____________________

4. Remove the rubber sheet.
5. Drop a lighted match into the jar.
6. Cover the jar with the sheet.
7. Move the sheet up and down.

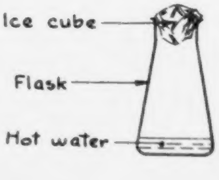
Observations: ____________________

Materials ACTIVITY II.

Flask
Hot water
Ice cube

Procedure

Set up the materials as shown:



Observations: ____________________

____

Questions

ACTIVITY I.

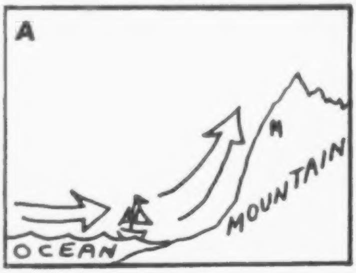
1. The water in the jar (increased, decreased)________the humidity.
2. Moving the sheet down (expanded, compressed)________the air.
3. When the sheet moved up the air (expanded, compressed)________.
4. The expanding air becomes (warmer, cooler)________.
5. The burning match added________to the air.
6. A better cloud was formed when________was added to the air.
7. Two things that cause clouds to form are (heating, cooling)________ and________particles.

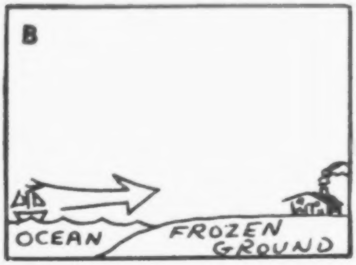
ACTIVITY II.

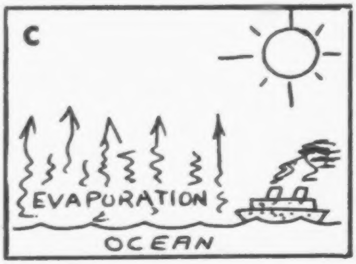
1. The hot water added________to the air in the flask.
2. The air touching the ice cube became________.
3. The water vapor in the flask formed a cloud or fog because it was ________.

Homework

1. Study each diagram. Tell what may form at A, B, and C. Explain each diagram in a few sentences.







2. Why do car exhausts and sewers form "clouds" of "smoke" that can be seen? What time of the year does this happen?

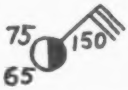
21. HOW DO WE MEASURE THE WEATHER FACTORS?

Outcomes

- The anemometer and wind vane measure wind speed and wind direction.
- The psychrometer is used to determine the dew point.
- Cloud heights and wind directions above the earth may be determined by means of balloons.
- Recording instruments keep a continuous record of the weather.

Motivation

Draw this weather station on the chalkboard.



Show the pupils an anemometer. Ask them if they can tell which item on the weather station is measured by this instrument.

Development

1. Elicit that the *anemometer* measures wind speed. Point out the three barbs or feathers on the weather station. Elicit that the wind is blowing about 30 miles per hour. Briefly point out how the inward curved surface of the anemometer cups receive the greater force of the wind so that the cups are caused to move.
2. Demonstrate a *wind vane.* Have the pupils find the symbol (on the weather map) that shows wind direction. Elicit that the station model shows that a northeast wind is blowing.
3. Ask the pupils how they think the weatherman measures the heights of clouds. Elicit that he can send up balloons to measure cloud heights. Point out that the direction of winds and their speeds above the earth can also be determined by means of balloons.

3a. Discuss the ceilometer which measures cloud heights by means of a vertical searchlight beam being scanned by a photoelectric cell.

4. Show the pupils a *psychrometer.* Have a pupil note that one thermometer bulb is covered with a gauze wick. The pupils should recall from the humidity lesson that the thermometers could be

used to measure the humidity of the air. Elicit the principles of its operation and demonstrate.

5. Point out that the weatherman uses the difference in degrees between the wet and dry bulb thermometers to calculate the dew point. Point out that the farther the two temperatures are apart the lower the dew point.
6. Ask the pupils to locate the dew point on the weather map.
7. Show recording instruments to the pupils. Have the pupils note the various parts of these instruments. They should note that each recording instrument is equipped with a chart on a drum, a clock, and a pen.
8. Point out the active elements of each recording instrument. Demonstrate the compound bar to illustrate the active element in a *thermograph*.

Summary

NOTE: When possible, refer to the weather station on the board.

1. How does the weatherman show wind direction and velocities near the surface of the earth? Name the instruments used to measure wind speed and direction.
2. How can we measure the height of clouds?
3. How can we measure wind speeds a mile above the earth?
4. Which number on the weather station represents the dew point? Name the instrument that helps us to determine the dew point.
5. What do we call an instrument that keeps a written record of temperatures? pressures? humidity?

Homework

1. Next to each word listed below write the name of the instrument that is related to it.
   - a. wind speed
   - b. wind direction
   - c. air temperature
   - d. humidity
   - e. dew point
   - f. precipitation
   - g. cloud height
   - h. air pressure

2. *Report on the various types of recording instruments used by the Weather Bureau. Tell what they measure and the principles of their operation.*

Materials

Wind vane
Anemometer
Barometers (liquid and aneroid)
Wet and dry bulb thermometers (psychrometer)
Recording instruments (thermograph, barograph, hygrograph)

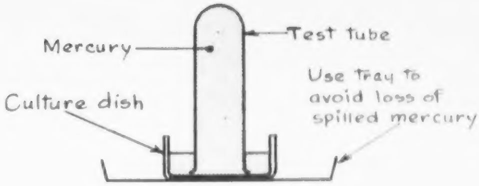
22. WHY IS THE BAROMETER AN IMPORTANT WEATHER INSTRUMENT?

Outcomes

- The mercury barometer measures air pressure by balancing a column of mercury with a column of air having the same weight.
- The aneroid barometer is a liquidless barometer.
- A falling barometer indicates the approach of bad weather or a low pressure system.
- A rising barometer indicates good or fair weather or the approach of a high pressure system.
- Air pressure instruments show pressure in inches or millibars.

Motivation

1. Prepare a setup as shown in the diagram. (See next page.)
2. Allow a pupil to note the heaviness of a stoppered test tube filled with mercury.
3. Remove the stopper and hold a glass plate firmly over the mouth of the test tube.
4. Carefully invert the test tube and place it in a culture dish partly filled with mercury.
5. Remove the glass plate.



Development

1. Draw a diagram on the chalkboard showing the various parts of the demonstration.
2. Ask the pupils, "What is keeping the mercury from flowing out of the test tube?" Elicit that the air pressure on the mercury in the dish is greater than the downward pressure in the test tube.
3. Elicit that air pressure could probably support a much taller column of mercury. Have the pupils recall from Lesson 8 that air pressure exerts a push of about 15 lbs/sq. in. at sea level. Point out that a column of mercury about 30 inches high exerts a pressure about 15 lbs/sq. in.
4. Show a commercial ***barometer*** (or prepare a mercury barometer using a mercury barometer tube). Have the pupils measure the height of the mercury column. They should note that it is about 30 inches high.
5. Note the construction of the liquid barometer. Guide the pupils to the understanding that the column of mercury is supported by outside air pressure. The pupils may place a drawing of the barometer in their notebook.

5a. Discuss the need for a dense liquid in the barometer. Relate the story of Von Guericke's water barometer.

6. Point out that the weatherman uses other units besides inches to show air pressure. These are called ***millibars.***
7. Show the pupils how millibar readings are shortened for convenience when placed on weather maps. Give a few examples such as 1015.0 is shortened to 150 by dropping the 10; 1025.5 becomes 255; and 1002.5 becomes 025.
8. Point out that normal sea level pressure is 29.92 inches or 1013.2 millibars.

9. Demonstrate an *aneroid barometer*. Some pupils may have one of these hanging on the wall at home. Elicit that it, too, shows air pressure.

9a. *Ask, "Is it possible to use an aneroid barometer to measure height above the ground?"*

Compare the aneroid barometer to altimeters which are the same instrument calibrated to show height above sea level by pressure differences.

10. Point out that the aneroid is a liquidless barometer. Tell the pupils that a "springy" tin can inside pushes in and out as air pressure changes. Compare the tin can to a squeezed rubber ball which recovers its original shape when pressure is released.

11. Have the pupils note that many aneroid barometers indicate the type of weather that should accompany certain pressures. In general, the pupils should note that high pressure means good or fair weather and low pressure indicates stormy weather.

Summary

1. How does a mercury barometer measure air pressure?
2. What units are used to measure air pressure?
3. What is a short way of writing these air pressures: 1001.0 and 1010.0?
4. What do we call the liquidless barometer? Explain how it works.
5. What kind of weather should we expect with a low pressure reading on the barometer?

Homework

1. Make a labelled drawing of a mercury or aneroid barometer. Explain how it works.
2. Write each of these millibar readings in the shorter form.

   a. 1000.0 b. 1008.0 c. 1030.0

3. Write these shortened millibar readings in the long form.

   a. 025 b. 250 c. 005

Materials

Tray
Small glass plate
Test tube and stopper
Yardstick
Culture dish (thick-walled)
Mercury
Commercial barometer — mercury and aneroid

23. WHERE DOES OUR WEATHER COME FROM?

LABORATORY LESSON

Outcomes

- Air masses are large sections of the atmosphere which have uniform temperature and humidity characteristics throughout.
- Air masses form when stationary air takes on the characteristics of the uniform land or sea areas over which they are sitting.
- As air masses move, they transfer their characteristics (weather) to the surface over which they are passing.

Motivation

1. Ask two pupils on opposite sides of the room to pretend that a heater is pointed at one pupil and an air conditioner is pointed at the other pupil. Elicit from pupils how they feel.
2. Pretend to switch the heater and the air conditioner around. Ask the pupils how they feel now.

Development

1. Elicit from the pupils that the way they felt depended upon the temperature of the air blowing upon them.
2. In turn, the pupils should realize that the temperature of the air depended upon the source of heat it was in contact with.
3. Distribute the material and Worksheets. Guide the pupils in performing the laboratory activity. Based on this investigation, they will discover that the air mass assumes the characteristics of the source region.

4. Using a map of the world, have the pupils identify the polar and tropical regions as the sources of the *air masses.*

Summary

Reinforce the concept that masses of air in contact with these regions will acquire their characteristics and be known as air masses.

Ask what would happen if these different air masses moved over the same locality, one right after the other.

Materials

Map of the world

Enrichment

If time permits, develop with the pupils the other air masses; for example: North Atlantic, Gulf Region, Continental Tropical, etc.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 23

Problem: How are air masses formed?

Materials

2 thermometers
2 beakers
3 to 5 ice cubes
200 ml of 100°-110° water
2 cloth strips, cobalt chloride treated (pink when moist, blue when dry)
2 pieces of oaktag (to cover each beaker)
Scotch tape

Procedure

1. Put the ice cubes in one beaker.
2. Attach a thermometer to the side of the beaker with the bulb just above the ice cubes. Use scotch tape.
3. Hang a strip of the cloth over the side of the beaker. Make certain the cloth does not touch the ice cubes.
4. Cover the beaker with a piece of oaktag.

5. Add about 200 ml of warm water to the other beaker.
6. Attach the second thermometer so that the bulb is about one-half inch above the water level.
7. Hang a strip of cloth over the side of the beaker. Do not let the cloth touch the water.
8. Cover the beaker.
9. Record the readings of each thermometer for 8 minute intervals.

Observations

	TABLE A (ICE CUBES)			TABLE B (WARM WATER)		
MIN.	TEMP.	STRIP COLOR	APPEARANCE OF JAR (INSIDE)	TEMP.	STRIP COLOR	APPEARANCE OF JAR (INSIDE)
Start						
1						
2						
3						
4						
5						
6						
7						
8						

Conclusions

1. The air in the ice cube beaker became ____________________ and ____________________.
2. The air in the warm water beaker became ____________________ and ____________________.

Summary

1. What did this experiment show? ____________________
2. What does this tell us about air masses? ____________________

Homework

1. What kind of areas would produce the following air masses
   a. warm and dry
   b. warm and humid
   c. cold and dry
   d. cold and humid
2. What type of air mass is affecting your weather right now?

24. HOW DO FRONTS CHANGE OUR WEATHER?

Outcomes

- The leading edge of an air mass, generally hundreds of miles long, is called a front.
- A cold front and warm front have different characteristics.
- The arrival of a front indicates a change in the weather.
- The weather clears after the passage of a front.

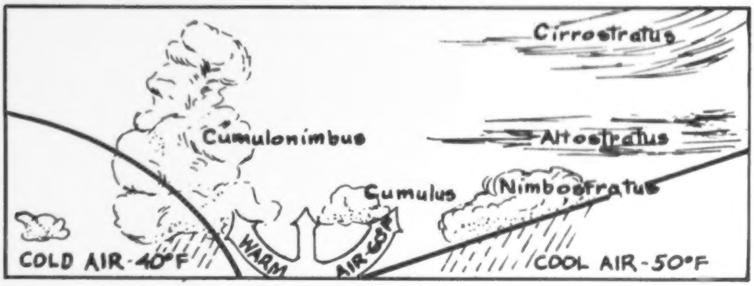
Motivation

Why does the temperature sometimes drop suddenly 10 to 15 degrees on a hot day?

Development

1. Have the pupils recall that air masses are packages of air with uniform temperature and humidity, different from the surrounding air and moving in certain general directions.
2. Elicit from the pupils that the word *front* is derived from the leading edge of the advancing air mass.
3. Develop the concept that warm and cold fronts are relative to the weather in a particular locality.
4. Ask for the characteristics of a cold air mass — higher pressure, dry, lower temperature; and a warm air mass — lower pressure, moist, higher temperature. Develop with the pupils the reasons that the arrival of a front can cause bad weather. Elicit from the students that when warm moist air comes in contact with colder air, condensation (clouds) and precipitation (rain and snow) may result.

5. Draw on the chalkboard, a cold front and a warm front.



5a. Elicit from the pupils the conditions on both sides of a front with regard to temperature, wind direction, wind velocity, dew points and air pressure.

Elicit with the aid of the diagram that the changes in a cold front are more dramatic, the action taking place in a relatively short time and the front moving rapidly by. Point out that thunderstorms usually accompany cold fronts and that hail may be a feature of the storm.

6. Elicit with the aid of the diagram that a warm front moves in more slowly. Both the clouds and the rain or snow that may follow will continue for a longer period than in the cold front.

7. Develop the concept that the bad weather will move along with the front and is generally confined to the front. After the front passes by fair weather will prevail, either that of the warm air mass or the cold air mass (whichever remains behind). Emphasize that the air masses do not mix, and remain intact.

8. Write on chalkboard the symbols for cold front and warm front.

8a. Write on chalkboard the symbols for stationary front and occluded front, and indicate their meaning.

Summary

1. What is a front?
2. Why does a front usually bring bad weather?
3. Why does the weather clear after the passage of a front?

Homework

1. Describe what happens when a cold front moves into an area.
2. Describe what happens when a warm front moves into an area.
3. Why does the weather in a cold front change more rapidly than in a warm front?
4. *What is a stationary front?*

25. *HOW CAN WE SHOW OUR LOCAL WEATHER ON A STATION MODEL?

LABORATORY LESSON

Outcomes

- A station model shows all the weather factors at a particular station at one time.
- Special instruments are used to measure the weather factors.

Motivation

Ask pupils, "What's the weather like outside?"

1. List the various weather conditions as described by the pupils.
2. Tell the pupils that today they are going to act as weathermen. Elicit the need for accurate observations. Ask the pupils how the weather can be measured accurately.
3. Draw the Weather Observation Table on the chalkboard. Distribute Worksheets which contain the same table.
4. Measure the weather factors as follows:
   a. Sky condition: Have 2 pupils go to the window to observe the sky condition.
   b. Wind direction and wind speed: Have the same pupils report on wind direction by looking for flags flying, smoke blowing, etc. Wind speed may be approximated as follows:

      5 miles/hr. — leaves or branches hardly moving

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* Only for classes programmed for five periods

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15 miles/hr. — raises dust and small paper, small branches move
25 miles/hr. — large branches move; winds whistle or howl

Elicit that accurate measurements are made by means of anemometers and wind vanes.

c. Precipitation: rain or snow, if any.

d. Pressure: Have pupils take a reading of the mercury barometer and compare the reading with the aneroid barometer.

e. Temperature and dew point: (Point out that because of convenience the indoor temperature and dew point will be used.) Have pupils read the temperature and then determine the dew point by means of the dew point apparatus.

5. When pupils have completed the Worksheets, draw the completed station model (with pupil assistance) on the board. Have pupils compare their drawings with the one on the board.
6. If time permits, determine the relative humidity by means of the psychrometer and relative humidity table.

Summary

How does the weatherman get the data for the station model?

(May be duplicated for use by pupils)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 25

Problem: How can we construct a station model showing our weather?

Procedure

1. Measure the various weather factors using instruments and other means.
2. Record your observations in the table below:

WEATHER OBSERVATIONS   Station_____ Date_____ Time_____

Temp.	Dew Point	Press.	Sky Conditions	Wind Direction	Wind Speed	Precip.	Other

3. Place the observed weather factors around the station model drawn below:

Questions

1. Which weather factors were "guessed at" rather than measured?___________________________

2. Why is your classroom temperature and dew point different from that outdoors?____________________

3. Can you explain why a barometer does not have to be read outdoors to get an accurate air pressure reading?____________________

4. What do stations on weather maps show?____________________

Homework

Make up a station model from newspaper or television reports.

26. WHAT DOES A WEATHER MAP SHOW?

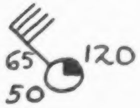
Outcomes

- **Weather maps show the weather at many locations at one particular time.**
- **Weather maps show the locations of highs and lows, and stormy areas.**

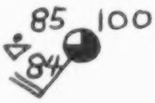
Motivation

Draw the two station models shown on the chalkboard. Ask the pupils, "How many differences can you find between these two weather stations?"

A



B



Development

1. As the pupils compare each station, have a chart, as shown, filled in on the chalkboard.

	A	B
Wind direction		
Wind speed		
Temperature		
Dew point		
Pressure		
Other		

2. Distribute the prepared sample weather map (this may be duplicated or may be prepared by transparency).
3. Elicit from the pupils that there are differences among the weather stations on each side of the jagged line or cold front. Point out that the temperature and wind differences are important in locating cold fronts. Have pupils label the cold front.
4. Have the pupils note the temperatures and dew points behind the cold front. Elicit that the air is cold and dry.
5. Ask the pupils to locate the warm front. Assist them by pointing out that steady rain or snow usually occurs ahead of the warm front. Have them label the warm front.
6. Show that the winds in-between the warm front and cold front are largely southerly. Elicit from the temperature readings and the dew points that this is a warm moist air mass.
7. Have the pupils note the 1020.0 or 200 isobar. They should observe that it travels through places having barometer readings of 1020.0 (200 on the map). Tell them that these lines are called ***isobars*** (iso-same; bar-pressure).
8. Encourage the pupils to find the labels *H* and *L*. Ask the pupils what they think these letters mean. Point out the pressures located in these areas. Elicit that *H* is a high pressure area and *L* is a low pressure area.

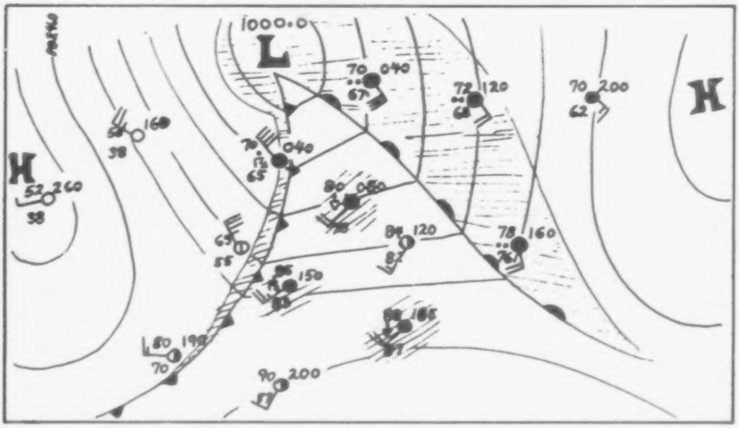
9. Have the pupils note the shaded areas, especially associated with the fronts and the low pressure region. Pupils may recall that low pressures indicate "bad" weather. Elicit that the shaded areas are having precipitation.
10. Remind the pupils that each station on the map recorded all of the information shown at the same time. The pupils should understand that the various stations are having different types of weather at the same time.

Enrichment

If time permits, discuss stationary fronts, occluded fronts, and pressure tendencies; cloud forms associated with cold and warm fronts, also.

Summary

SAMPLE WEATHER MAP


1000.0
L
H
H
70 040 67
72 120
70 200 62
54 160 38
70 040 65
52 260 38
80 050
84 120 82
78 160
65 55
150
185
80 190 70
90 200

1. What kind of weather is behind the cold front? What kind of weather is ahead of the warm front?
2. Name a station found in a cold, dry air mass.
3. What evidence is there that the area between the cold and warm front is a warm, moist air mass?

4. What do the letters H and L indicate?

5. How do you know that it is raining all along the cold front?

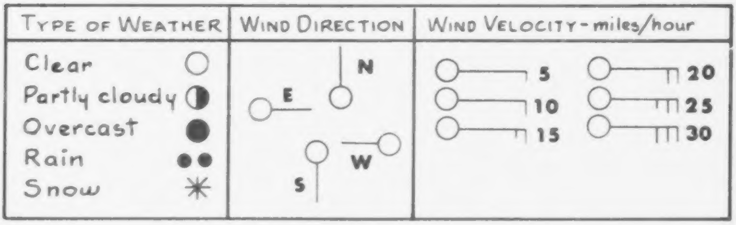
6. What is the reason for placing weather information on so many stations at one time?

Homework

1. Place the following information around the weather stations listed below. See table for symbols to be used.

STATIONS	PRESSURE	TEMP.	WIND DIRECTION	WIND VELOCITY	PRECIPITATION	SKY
Albany	1020.0	85	NW	30	NONE	Overcast
Buffalo	1015.0	60	SE	20	RAIN	Cloudy
Chicago	1035.0	75	SW	10	RAIN	Partly Cloudy

WEATHER STATION SYMBOLS


TYPE OF WEATHER
WIND DIRECTION
WIND VELOCITY - miles/hour
Clear
Partly cloudy
Overcast
Rain
Snow
N
E
S
W
5
10
15
20
25
30

27. HOW IS A WEATHER MAP CONSTRUCTED?

LABORATORY LESSON

Outcomes

- Many stations record their weather at the same time.
- Weather maps show the location of highs, lows, fronts and precipitation areas.

Motivation

1. Use the previous day's homework to reinforce the parts of the station model.
2. Tell the students that they are going to make their own weather maps.

Development

1. Distribute Worksheets and weather maps.
2. Assist the pupils with the filling-in of a few weather stations. Have the pupils complete the remaining stations and the questions at the end of their Worksheet.

Summary

1. Elicit from the pupils the locations of fronts, highs, and lows and precipitation areas.

1a. Have the pupils label the isobars with the pressures they represent.

2. Discuss the questions at the end of the Worksheet.

Homework

1. Add the wedges and half-circles that show cold and warm fronts.
2. Label the highs, lows, and fronts.
3. *Label the various air masses that are on the map.*
4. *Compare the weather between Huntsville and Charlotte; and between Pittsburgh and New York City.*

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 27

Problem: How can we construct a weather map?

Materials

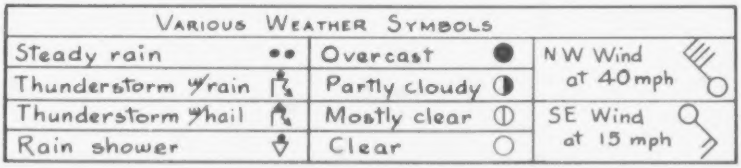
Blank weather map	Weather station data

Procedure

WEATHER STATION DATA

		Wind Direction	Wind Velocity	Pressure	Temp.	Dew Point	Cloud Cover	Present Weather
New York	1	SE	25	1012.0	75	73	Overcast 10/10	Steady Rain
Boston	2	SSE	20	1012.0	78	76	Overcast 10/10	Steady Rain
Rochester	3	SE	30	1004.0	75	73	Overcast 10/10	Steady Rain
Pittsburgh	4	NW	40	1006.0	60	57	Overcast 10/10	Thunderstorms
Chicago	5	NW	30	1018.8	50	40	Clear	
Minneapolis	6	W	10	1026.0	40	30	Clear	
Denver	7	NW	5	1036.0	45	30	Clear	
St. Louis	8	NW	15	1024.0	60	50	Mostly Clear 1/10	
Huntsville	9	NW	30	1018.5	80	78	Overcast	Thunderstorms With Hail
Charleston	10	S	15	1024.0	85	84	Overcast	Rain Shower
Charlotte	11	SW	20	1016.0	85	83	Mostly Cloudy 8/10	Rain Shower
Washington D.C.	12	SE	20	1012.0	78	75	Overcast	Steady Rain

1. Place the data for each weather station on the station models in the blank weather map.
2. Use this key to help you fill in some of the information.

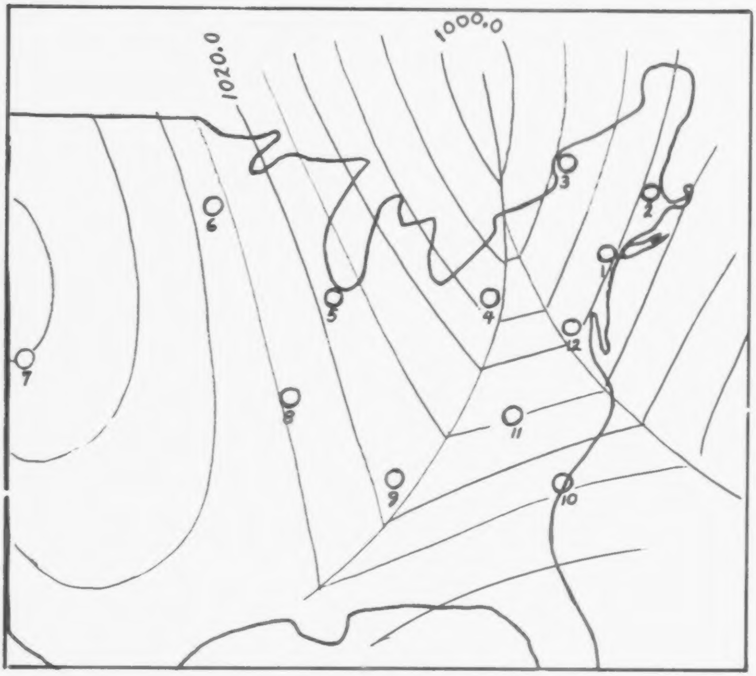


VARIOUS WEATHER SYMBOLS

Steady rain	••	Overcast	●	NW Wind at 40 mph
Thunderstorm w/rain		Partly cloudy	◑	
Thunderstorm w/hail		Mostly clear	⦶	SE Wind at 15 mph
Rain shower		Clear	○	

Questions

1. Which city has the highest air pressure? ______



2. Which station has the lowest air pressure?____________________

3. Name two cities that have high humidities.____________________

4. Name two cities that have low humidities.____________________

5. a. Name 2 cities that are having thunderstorms.____________________
   b. Name the type of front that is close to them.____________________

6. a. Name 2 cities that are having steady rain.____________________
   b. Name the front that they are closest to.____________________

28. WHAT IS THE WEATHER FOR TOMORROW?

Outcomes

- The meteorologist uses the weather map to forecast the weather.

- If we have basic information, we can forecast the weather with some degree of accuracy.

Motivation

How does our weatherman make up the weather forecast?

Development

Note: Use official weather maps, or tell students to bring in a daily weather map clipped from a newspaper. If necessary, duplicate copies for distribution.

1. Have the pupils recall that the changing pattern of air masses determines our weather. Air masses hundreds of miles away today, make up our weather for tomorrow.
2. Elicit from the pupils the need to have an overall picture of weather conditions throughout the country. Why?
3. "Does weather start at our boundaries?" Use a map of North America. Draw an outline map of the United States on the chalkboard. Have the pupils indicate where they would put weather stations, both land and sea, for complete coverage. Elicit from the pupils that many hundreds of stations would be necessary to make up a full picture.
4. Elicit the need for a central clearing bureau where all the data can be brought together in a unified picture.
5. Ask the pupils for suggestions as to the services performed by the Weather Bureau. Place the list on the chalkboard. Include:
    a. Issuing daily weather maps
    b. Daily, extended (5 day), and long range (30 day, etc.) forecasts
    c. Aircraft weather reports
    d. Agricultural advisory reports
    e. Storm warnings (hurricane and tornado)
    f. Fire weather warning service
    g. Flood control warning service
    h. Space program weather information.

6. Elicit from the pupils the need for frequent (4 times daily) and fast (radio and telegraph) reports.

7. Bring the attention of the pupils to the area they are in. "What does our weatherman do?" Include such activities as:
   a. Making observations and sending them to Washington
   b. Issuing daily weather forecasts
   c. Advising utility companies, outdoor sports and other outdoor activities about the weather for the next few hours.

8. Have pupils take out their weather maps (or provide them with maps). Tell them they are now weathermen. Confine their attention to a radius of about 1000 miles. Recall that wind brings weather. Guide them in a discussion based upon any fronts indicated, highs or lows shown, and a comparison of the weather factors in station models of various cities.

9. Elicit from the pupils the weather factors that they could use to forecast the weather for the local area. The list should include:
   a. changes in wind direction
   b. changes in wind speed
   c. changes in temperature
   d. changes in humidity
   e. changes in sky condition.

10. Ask the pupils to make a forecast, based on their information.

Summary

1. Why do we need a weather bureau?
2. What services does the weather bureau perform?
3. How does a weatherman forecast the weather?

Homework

1. Using yesterday's and today's weather maps, compare the weather factors shown in New York, Buffalo, and Chicago, Ill.
2. Compare your weather forecast with that of the Weather Bureau and with what actually occurs.

29. WHAT MAKES OUR WEATHER IN NEW YORK CITY?

Outcomes

- Most rain and snowstorms come from the west or southwest.
- New York weather conditions are generally moderate because of its latitude and nearness to the ocean.
- New York has thunderstorms at times, especially during the summertime.
- Hurricanes, born near the Equator, occasionally bring destructive winds to the city in the late summer or fall.

Motivation

Ask the pupils, "How many different kinds of weather does New York have?"

Development

1. Elicit the following list from the pupils:
   a. rain and snowstorms
   b. thunderstorms
   c. heat waves and cold waves
   d. hurricanes
2. Have the pupils recall the type of pressure system that identifies bad weather. Elicit that our rain and snow come from an advancing warm front. Point out that these storms move in from the general direction of the west and southwest.
3. To develop the concept of summer thunderstorms elicit that moist, hot air rises and cools to form clouds. Show by means of a diagram the development of a cumulus cloud. Point out that when cumulus clouds reach great heights they build up electrical charges which result in thunder and lightning.
4. Compare an advancing cold front, bringing a mass of heavy cold air, to a snow plow or shovel. Point out that the cold front scoops up warm, moist air producing towering cumulus clouds. Elicit that these clouds could produce thunder and lightning and short periods of heavy precipitation over our city.

5. Compare the temperature differences of the heated land and water. Elicit that cool heavy air over the oceans moves in over the land to replace the light warm air. Have pupils recall the land and sea breezes from the lesson on winds.

5a. Discuss the shifting of the wind belts.

6. Compare the extremes in temperature inland with more moderate coastal conditions. Because the ocean holds most of its heat during the winter while the land becomes frozen, (compare the ocean to a radiator) point out that the warm ocean water helps to keep the air temperature over the land from dropping too much.

7. Discuss a hurricane's fury with the pupils. Elicit that we seldom get hurricanes in New York. Some pupils may have experienced hurricanes. Have them relate their experience. Point out that hurricanes are born in the hot, very moist air of the oceans near the equator. Elicit that the general track of hurricanes is towards the United States, that they curve out to sea and that they may occur in the late summer or fall.

7a. Discuss the formation of a hurricane, its wind speed and the "eye". Elicit how hurricanes are "tracked".

8. Compare New York's general climate (temperate) with that of Florida and Alaska. Establish latitude (41° for New York City) as an important factor in determining the usual weather conditions of a location.

Summary

1. How do thunderstorms form?
2. Where do our snowstorms come from? Explain.
3. Why don't hurricanes hit New York every year?
4. *Describe the characteristics of a hurricane.*

Homework

1. Bring in a report on one of the following

   a. thunderstorms b. tornadoes c. hurricanes

2. Find where the hottest and coldest parts of the United States are.

30. *HOW CAN WE PREDICT THE WEATHER?

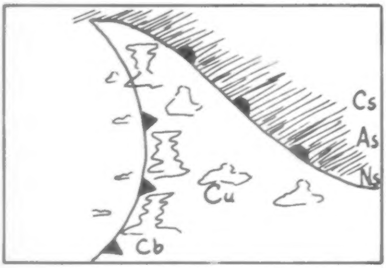
LABORATORY LESSON

Outcomes

- The movement of storm systems is used to forecast the weather.
- Wind directions and cloud types are helpful for the average person in determining the weather.

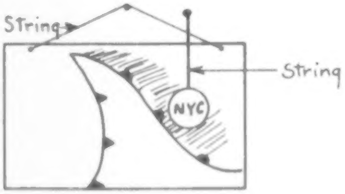
Motivation

1. Prepare a large piece of oaktag as shown.
2. Ask the pupils, "What does this drawing represent?"



Development

1. From their previous lessons, elicit that it represents a low pressure system. Have the pupils recall that lows or storm systems move across the country generally from west to east.
2. Over the illustration at the chalkboard, suspend a small circle labelled N.Y.C. as shown:



3. The pupils should note that N.Y.C. is ahead of the warm front and that it is raining.
4. Move the large oaktag so that New York City is in between the warm and cold fronts.

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* Only for classes programmed for five periods

5. Move the oaktag so that New York City is behind the cold front. The pupils should note that New York City is covered by a large mass of cold air.
6. Have the pupils note the type of clouds found in each area of a low pressure system.
7. Tell the pupils that they are going to use "real" weather maps to do their own weather forecasting for New York City.
8. Distribute pupil Worksheets. Assist pupils with the reading and understanding of the directions.

Summary

1. If the wind is from the east or southeast, what kind of weather could you expect?
2. If the wind is from the south, what kind of weather could you expect?
3. When the wind gets strong and blows from the northwest, what kind of weather should follow?

Materials

See diagrams under motivation and development.

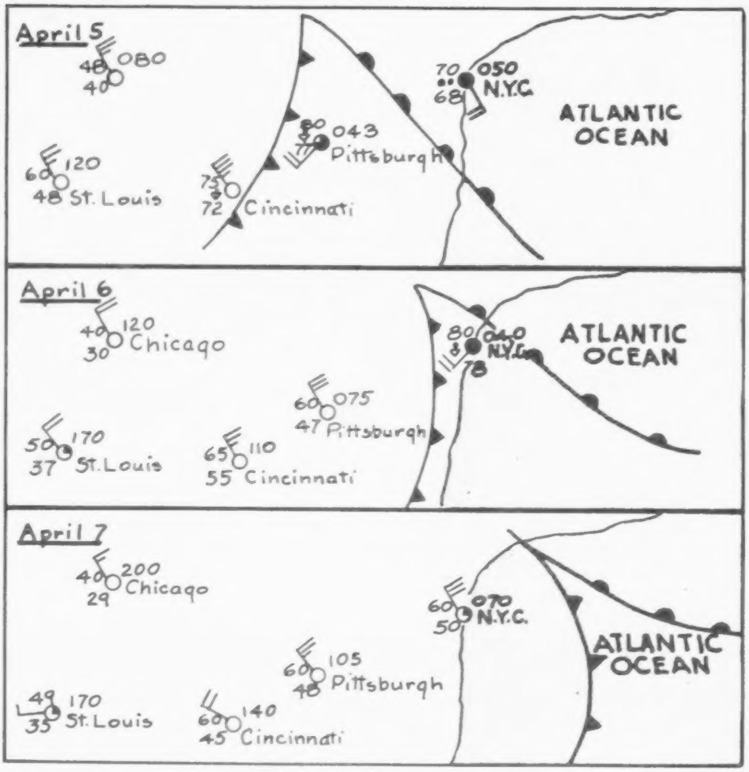
(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — EARTH SCIENCE: LESSON 30

Problem: How does the movement of a LOW help in forecasting the weather?

1. Weather conditions in N.Y.C. on Apr. 5, 6, and 7 from weather chart: (p. 366)

	WIND DIRECTION	WIND SPEED	TEMPERATURE	DEW POINT	PRECIPITATION
April 5					
April 6					
April 7					


April 5
48 080
40
60 120
48 St. Louis
75
72 Cincinnati
80 043
70
Pittsburgh
70 050
68 N.Y.C.
ATLANTIC OCEAN
April 6
40 120
30 Chicago
80 040
N.Y.C.
78
ATLANTIC OCEAN
60 075
47 Pittsburgh
50 170
37 St. Louis
65 110
55 Cincinnati
April 7
40 200
29 Chicago
60 070
50 N.Y.C.
ATLANTIC OCEAN
60 105
48 Pittsburgh
49 170
35 St. Louis
60 140
45 Cincinnati

Question:

1. What kind of weather is ahead of a warm front?
2. What happens to the wind direction when a warm front goes through a station?
3. The clouds help us to forecast the weather. Match the following clouds to the type of weather that they are associated with.

Cirrostratus	a. steady rain is falling
Nimbostratus	b. rain shower
Cumulus	c. steady rain is approaching
Cumulonimbus	d. cold and dry
	e. thunderstorms
	f. hot and muggy
	g. hail

Homework

1. Collect the weather maps from a newspaper for a few days. Paste them one beneath the other on a long strip of paper. Color in the center of the low. See how far it moves each day. Note the direction of movement of the low.
2. Look at tomorrow's newspaper weather map. Forecast the weather for the following day by using the learnings in this lesson as a guide.

Appendix

SUGGESTED REFERENCES

For the Teacher

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Byers, R. *General Meteorology*. New York: McGraw Hill, 1959.

Forrester, Frank H. *1001 Questions Answered About the Weather*. New York: Dodd, Mead, 1957.

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Fisher, R. M. *How About the Weather*. New York: Harper and Brothers, 1951.

Longstreth, T. **Morris**. *Understanding the Weather*. New York: Collier Books, 1962.

Namowitz, S. N. *Earth Science*. New York: D. Van Nostrand, 1961.

Ramsey, W. L., **et al**. *Modern Earth Science*. New York: Holt, Rinehart and Winston, 1965.

Schneider, H. *Everyday Weather and How It Works*. New York: Whittlesey House, 1951.

ENRICHMENT ACTIVITIES

Subject Matter

1. Investigate the adiabatic lapse rate, and its relationship to cloud formation and pressure systems.
2. Report on the mechanics of temperature inversions, especially as related to air pollution.
3. Study the climates of various areas, and their effect on weather conditions.
4. Investigate the effect of ocean currents on weather.

Pupil Projects

1. Help to set up a weather station at your school, and to prepare weather information on a regular basis.
2. Construct recording weather instruments, and use them at home.
3. Collect daily weather maps for a period of one week. Note the movements of highs and lows, and weather associated with these movements.
4. Prepare charts showing isotherms and how they change with the seasons.

Trips

1. Air Pollution Center
2. Hall of Science
3. U.S. Weather Bureau

Research

1. Prepare weather data for a number of stations across the United States. Plot the data, including isobars and fronts, and predict weather based on your data.
2. Investigate artificial rain-making as an attempt to solve the problem of droughts. Study the mechanics of various methods of rainmaking.
3. Investigate unusual storms such as hurricanes and tornadoes. Prepare charts and maps showing location and frequency.

TEST QUESTIONS

Multiple Choice

Write the letter preceding the correct answer.

_________ 1. The cloud type most closely associated with the formation of hail is

a) cirrus
c) cumulonimbus
b) altostratus
d) nimbostratus

__________ 2. The heaviest precipitation usually occurs in the

a) doldrums
b) horse latitudes
c) trade winds
d) polar easterlies

__________ 3. The area of precipitation is usually largest

a) ahead of the cold front
b) ahead of the warm front
c) behind the cold front
d) behind the warm front

__________ 4. The boundary between air masses is called

a) a divide
b) a front
c) an isobar
d) an isotherm

__________ 5. The number of "feathers" on a station model symbol indicates the

a) barometric pressure
b) temperature
c) wind direction
d) wind speed

__________ 6. Barometric pressure recorded on a weather map as 189 indicates a pressure, in millibars, of

a) 189
b) 918.9
c) 1018.9
d) 1890

__________ 7. Solar energy is transferred through space by

a) absorption
b) conduction
c) convection
d) radiation

__________ 8. Descending air currents are

a) warmed by expansion
b) warmed by compression
c) cooled by expansion
d) cooled by compression

__________ 9. Water vapor leaves the air by a process called

a) condensation
b) evaporation
c) radiation
d) convection

__________ 10. Which part of the air varies most from day to day?

a) carbon dioxide
b) nitrogen
c) oxygen
d) water vapor

__________ 11. More than 50% by weight of our atmosphere is found in the zone of the

a) exosphere
b) troposphere
c) stratosphere
d) ionosphere

________12. Balloons that rise at known rates are usually used by weather observers to determine

a) air pressure
b) ceiling
c) dew point
d) visibility

________13. The dew point at a given time is 60°F. When the air temperature lowers to the dew point, the relative humidity is

a) 0%
b) 30%
c) 60%
d) 100%

________14. Rainfall can be encouraged by

a) exploding cannon
b) using atom bombs
c) using high frequency sound
d) seeding clouds

________15. Which is an example of a low, threatening cloud that may bring snow or rain

a) altocumulus
b) altostratus
c) cirrocumulus
d) nimbostratus

________16. Trade winds generally blow

a) away from the equator
b) toward the equator
c) toward the poles
d) only in the southern hemisphere

________17. Which belt has the widest range of weather conditions

a) trades
b) doldrums
c) horse latitudes
d) westerlies

________18. Heavy daily rains are characteristic of the

a) doldrums
b) horse latitudes
c) trades
d) westerlies

________19. On a hot summer day sea breezes occur because of relatively

a) low pressure over water
b) high temperature of the water
c) low pressure over land
d) low temperature of the land

________20. Cirrus clouds are

a) high feathery clouds
b) rain clouds
c) thunder clouds
d) clouds of smoke

__________21. Ice is likely to form quickly on highways when
a) hail falls during a thunderstorm
b) rain falls when the surface of the road is cooler than 32°F
c) snow falls during a blizzard
d) snow falls when the surface of the road is warmer than 32°F

__________22. The clouds within which severe turbulence usually occurs are
a) cirrostratus
b) cirrus
c) cumulonimbus
d) stratus

__________23. Which type of cloud is composed principally of ice crystals
a) cirrus b) cumulus c) nimbus d) stratus

__________24. The lowest recorded temperature in the United States occurred
a) along the east coast
b) along the west coast
c) in the interior
d) on the coastal islands

__________25. Information on conditions of air above the clouds is gained by means of
a) radar
b) mercury barometers
c) radiosondes
d) anemometers

__________26. The cloud ceiling is most readily determined at night by the aid of
a) helium-filled balloons
b) a barometer
c) a sounding lead
d) a searchlight and clinometer

__________27. Frost is most likely to occur in valleys on a night that is
a) cool, clear, calm
b) cool, cloudy, windy
c) cool, cloudy, calm
d) cool, clear, windy

__________28. Clouds and fog differ principally in
a) amount of water droplets
b) density
c) amount of dust
d) height above the ground

__________29. The relative humidity of an air mass will decrease if the air mass is

a) cooled quickly
b) warmed by compression
c) forced over a colder air mass
d) lifted 15,000 feet above sea level

__________30. Rain passing through layers of air below 32°F may form

a) dew
b) frost
c) sleet
d) snow

__________31. Compared with a land area, a water area

a) heats more rapidly and cools more rapidly
b) heats more rapidly and cools more slowly
c) heats more slowly and cools more rapidly
d) heats more slowly and cools more slowly

__________32. Which of these cities has the greatest annual range in temperature?

a) Boston
b) Minneapolis
c) New York City
d) New Orleans

__________33. In the winter, the coldest areas are usually

a) oceans
b) hilltops
c) island coasts
d) continental interiors

__________34. Air pressure is usually highest when the air is

a) cool and dry
b) cool and moist
c) warm and dry
d) warm and moist

__________35. An isobar connects places with the same

a) altitude
b) pressure
c) temperature
d) wind speed

__________36. An atmospheric pressure of 29.92 inches of mercury is equivalent to a pressure in millibars of

a) 992
b) 1000
c) 1013.2
d) 14.7

__________37. Which covers the greatest area at any one time?

a) an air mass
b) a cold front
c) a tornado
d) a hurricane

__________38. The base of a cloud represents a point in the atmosphere where the relative humidity is

a) 0%
b) 50%
c) 75%
d) 100%

__________39. A hygrometer measures

a) cloudiness c) wind velocity
b) rainfall d) relative humidity

__________40. In artificial rainmaking, a material commonly used to provide nuclei of condensation is

a) sulphur c) table salt
b) silver iodide d) silicon

__________41. Much of the heat gained by the earth during the day is lost at night by

a) conduction c) radiation
b) convection d) reflection

__________42. The changing of a liquid to a gas is known as

a) sublimation c) evaporation
b) condensation d) convection

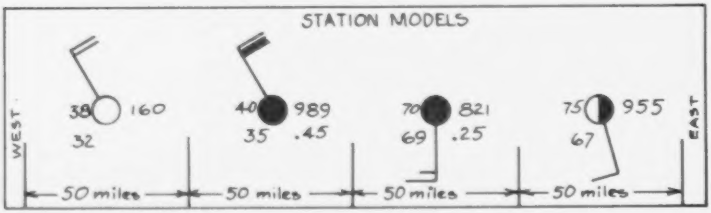
__________43. The troposphere receives most of its heat

a) by compression of the air
b) by compression of water vapor
c) directly from the sun
d) through contact with the earth's surface

__________44. An atmospheric pressure of 14.7 pounds per square inch may be recorded as a pressure of

a) 29.92 mb. c) 1031 mb.
b) 1013.2 mb. d) 1470 mb.

Questions 45 to 54 are based on the station model below.



__________45. The strongest wind is reported at station

a) A b) B c) C d) D

__________46. The temperature at station A is

a) 6°F b) 16°F c) 32°F d) 38°F

__________47. Station C reports a pressure of

a) 700 mb.　　c) 982.1 mb.
b) 821.0 mb.　　d) 29.92 inches

__________48. At station D the wind is blowing from

a) northeast　　c) southeast
b) northwest　　d) southwest

__________49. Station B has just experienced the passage of a

a) warm front　　c) stationary front
b) cold front　　d) hurricane

__________50. The relative humidity at station C is about

a) 0%　b) 25%　c) 70%　d) 98%

__________51. Heaviest rainfall in the past 6 hours was reported from station

a) A　b) B　c) C　d) D

__________52. Clear skies are reported from station

a) A　b) B　c) C　d) D

__________53. The next station to get a rapid change in weather will probably be

a) A　b) B　c) C　d) D

__________54. The station with the highest pressure is

a) A　b) B　c) C　d) D

Matching

Fill in the letter of the word or words in Column II which best match the statement in Column I.

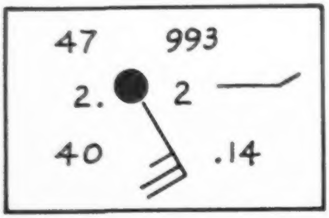
COLUMN I	COLUMN II
_____ 1. mercury column	a. isobar
_____ 2. continuous temperature record	b. anemometer
_____ 3. ceiling	c. barograph
_____ 4. surface wind speed	d. rain gauge
_____ 5. amount of precipitation	e. altimeter
_____ 6. equal atmospheric pressure	f. thermograph
_____ 7. location of thunderstorms	g. clinometer
_____ 8. indication of air pressure as height	h. radar
_____ 9. continuous pressure record	i. barometer
_____10. humidity	j. psychrometer

Completion

Write the word or expression that best completes the statements:

1. In winter, the temperature of ocean areas is usually__________ than that of land areas in the same latitude.
2. Two great wind belts that blow out of the horse latitudes are the __________ and __________.
3. Clouds are formed when moist air is cooled below the__________ point.
4. The ratio of the absolute humidity of a mass of air to its capacity is called__________.
5. The temperature at which air becomes saturated with water vapor is called the__________.
6. Most of the large deserts of the world lie in the__________wind belt.
7. Winds which reverse direction with the changing seasons are called __________.
8. Fill in all 10 blanks, based on the station model.

WEATHER ELEMENT	ACTUAL READING	INSTRUMENT USED
Air Pressure		
Air Temperature		
Wind Speed (Beaufort No.)		
Amount of Precipitation		
Wind Direction		



Modified True-False

Identify as True if statement is correct; if the statement is not correct change the underlined word to make the statement true.

__________ 1. As the latitude increases, the altitude of the troposphere decreases.

__________ 2. Ground or radiation fog is most likely to form when the sky is overcast.

__________ 3. Wind velocities usually increase with altitude.

__________ 4. As the temperature of cooling air approaches the dew point, the relative humidity increases.

__________ 5. Humid or moist air is lighter than dry air.

__________ 6. As air descends a mountain slope its temperature decreases.

__________ 7. Closely spaced isobars on a weather map indicate areas of low wind velocity.

__________ 8. As the altitude increases, the barometric pressure decreases.

__________ 9. Maritime polar air masses may originate over the North Pacific Ocean.

__________10. Rising air cools chiefly as a result of expansion.

__________11. As the difference in pressure between two stations increases, the wind speed decreases.

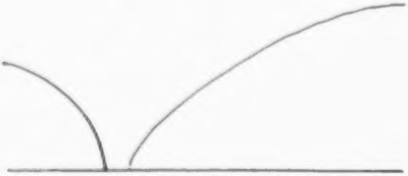
__________12. When a descending current of air compresses and warms, the amount of water vapor it can hold decreases.

__________13. A maritime polar mass usually brings humid weather to the eastern United States.

Essay

1. Using the diagram:

a. Label the warm front and the cold front.



   b. Indicate with arrows the direction of movement of the warm air along both fronts.

   c. Explain why clouds and precipitation usually occur along or near fronts.

2. At LaGuardia Airport, N.Y.C., these weather observations were made: sky overcast; barometer, 985.5 millibars; temperature, 64°F; wind northeast at Beaufort, force 6; visibility, 1 mile; weather, rain.

   a. Draw a station model correctly by indicating 5 of the weather factors.

   b. Name the instruments used to measure each of 5 of these weather factors.

3. Describe a procedure by which dew point may be determined.

4. Explain why the dew point is valuable in weather forecasting.

5. Explain why radiation fog disappears after sunrise.

6. Account for the formation of frost.

7. Explain why rising air currents may cause condensation of water vapor.

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